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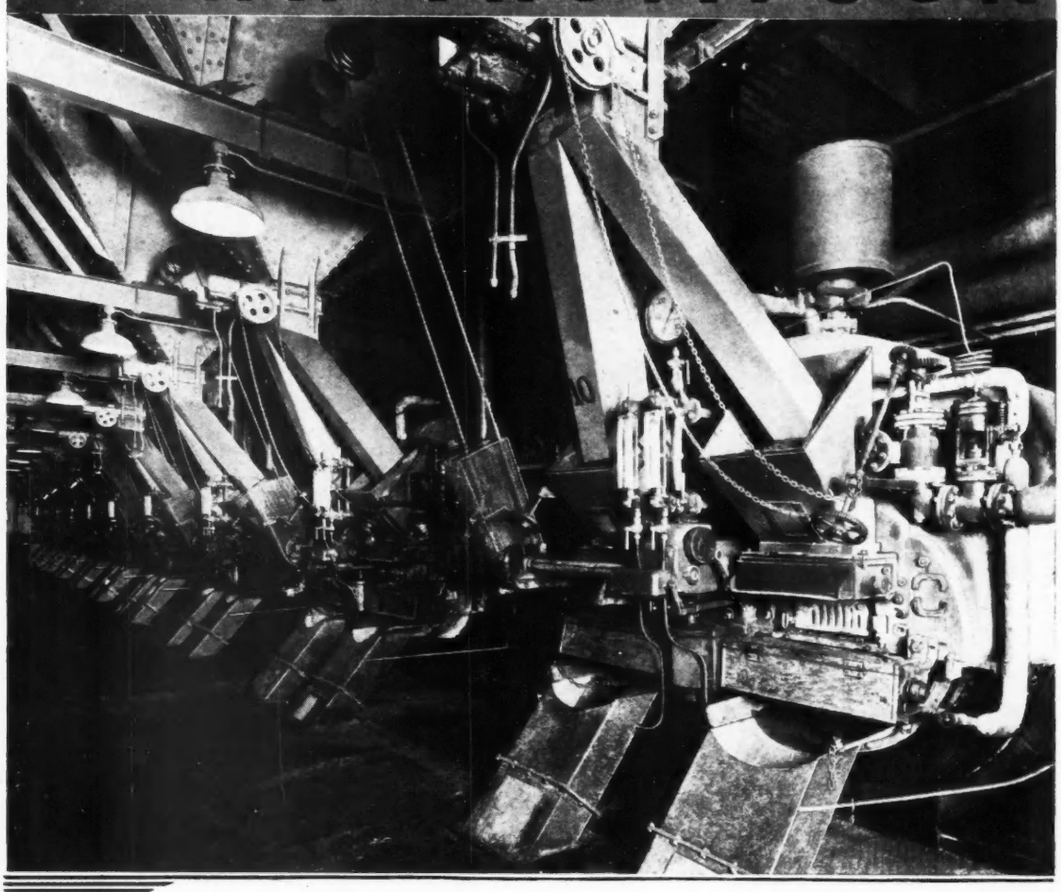

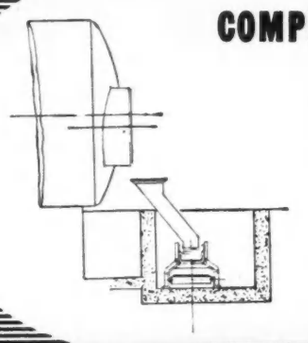

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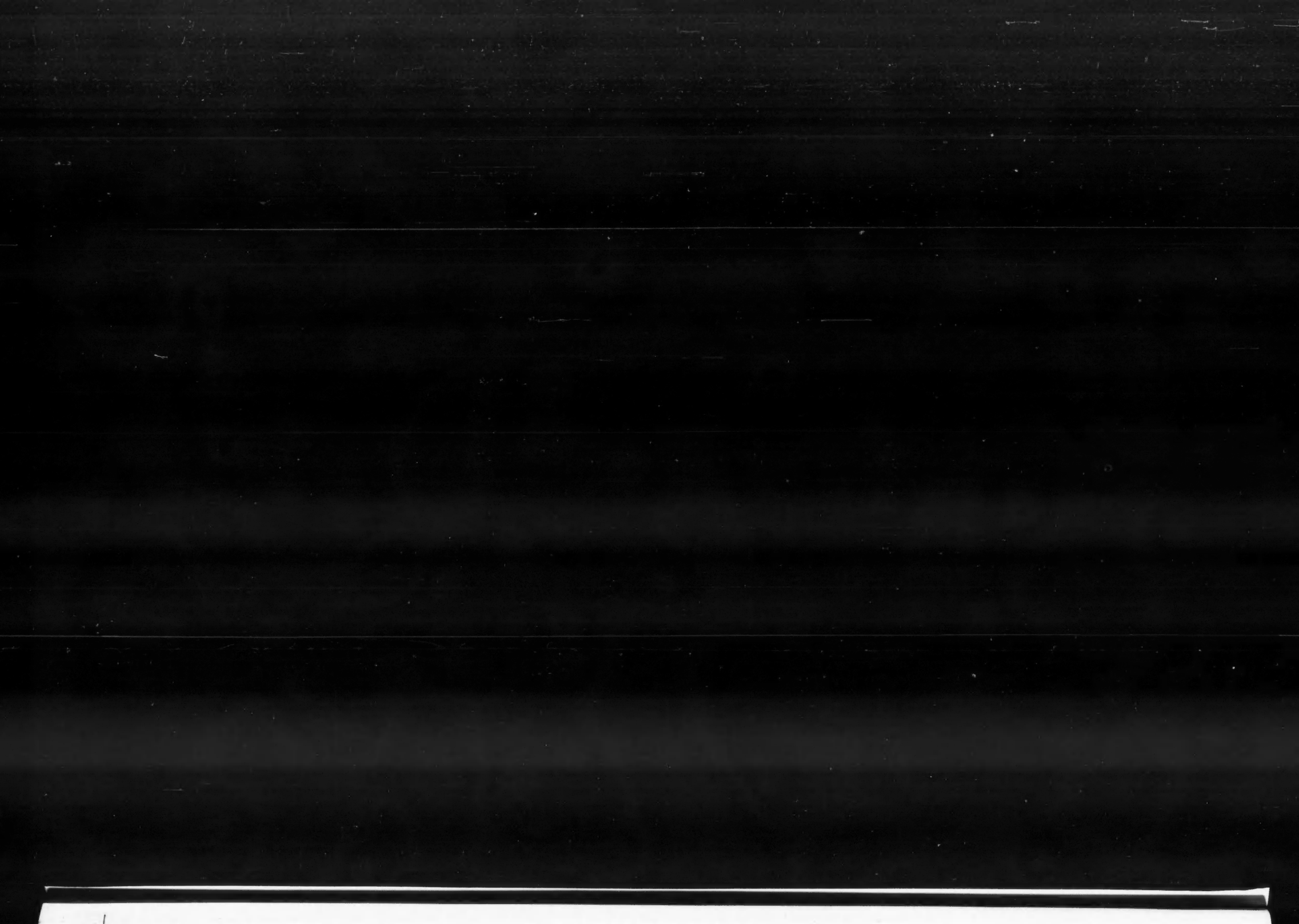


BOLTED CONNECTIONS IN STRUCTURES.

By A. M. HAMILTON, B.E.(N.Z.), M.I.C.E., M.I.Mech.E.

ALTHOUGH a bolted or screwed connection is one of the oldest methods of joining the parts of a machine or structure, it is only recently that the many advantages of this method have been appreciated. The author hopes to show that the friction induced by a tight bolt of adequate diameter is as elastically as one member, consisting of the plates, bolt, nut, and washer.

The holding of plates in rigid and intimate contact, due to frictional forces which prevent creep or slip, is usually necessary, of course, for the security and tightness of riveted boilers, ships' plates, etc. Tightness of the boiler against leakage of steam or water is due more to the tension of the rivets than to their pinning action. It is frequently supposed that there is a special merit in a rivet shank, which is swollen by hammering to fill the hole, compared with a bolt which will not act in this manner unless it fits tightly. This has led to the fallacy that

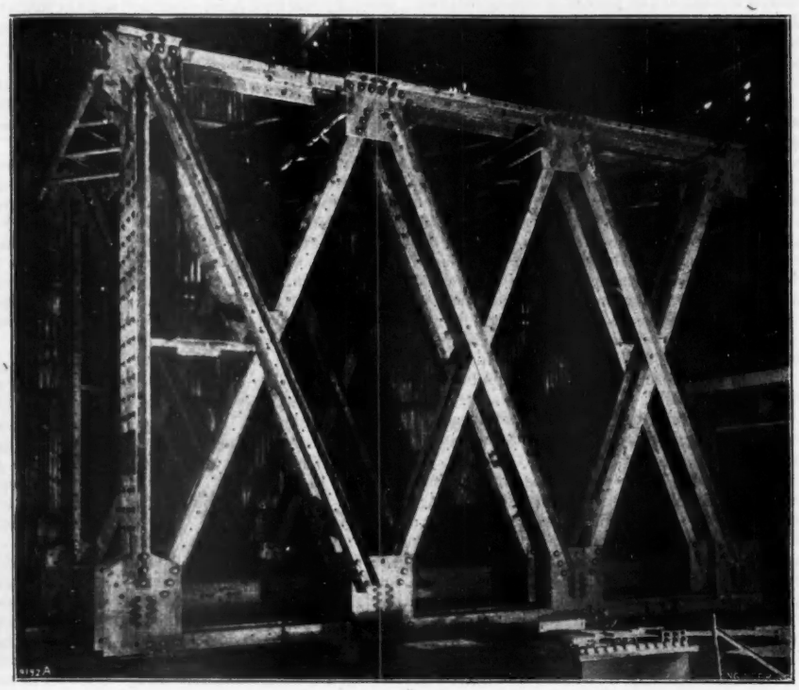


FIG. 1.

Fig.2.

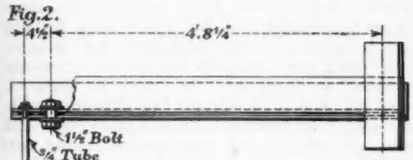
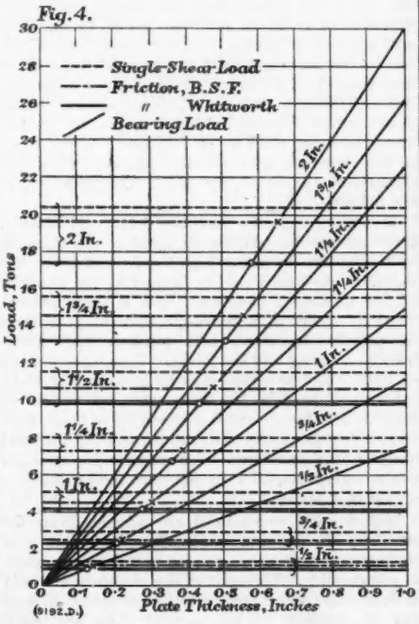


Fig.3.

important a factor as bearing and shear, and some rules for the design of bolted connections, which experience has shown to be reliable, are suggested.

The conventional rules for the design of bolted and riveted connections generally assume that the main function of a bolt or rivet is to withstand a shearing force across a section of the shank, and a pressure on the curved surface; and the influence of tension in the bolt or rivet, which causes friction between the joined plates, is not taken into account. Although, in text-books, such as Unwin's *Elements of Machine Design*, the latter forces were not ignored, they were only mentioned as an alternative consideration, because the friction had not been determined. Thus, bolted or riveted joints are generally regarded as a variant of the pin joint, where there is shear or bending due to pressures on the surfaces, but no tension in the shank, or friction arising from it. The conditions, however, differ considerably. When a bolt is tightened, there is a range of conditions varying from maximum bearing and shear stresses when slack, to little or none when the bolt is tight. If a bolted joint does not move or creep to the "pin" condition, it may be considered to behave

Fig.4.



all bolts except force-fit bolts are inferior to rivets. A few years ago, it was considered good practice to sacrifice some of the tensional strength of a bolt, by reducing the diameter of the threaded portion, to obtain a turned tightly-fitting bolt—although this involved additional expense in manufacture and extra effort in fitting the bolts. There are occasions, of course, when such force-fit bolts are appropriate, but they are not generally the best bolts for structures. The main object of a bolt in a structure is to provide adequate tensile strength, and for this purpose it must have a suitable cross-sectional area.

It has been found, in many tests, that there is often no mark on either the hole or the bolt shank, when a bolt is removed from a connection which has been stressed severely. This is particularly true of large bolts. It appears that even at high loads the members are held by friction, and it is therefore pertinent to inquire under what conditions a bolted connection will slip to the pin condition. The coefficient of friction, μ, between the plates, or between the bolt head, nut or washer, and plate, may be modified by the amount, composition, and condition of dryness of the paint, by the roughness of the surfaces, etc. Although it is not possible to suggest values for μ, covering all these conditions, it is possible to give an average value for unpainted, galvanised or zinc-sprayed surfaces, which is fairly constant for the "unmoved" condition. An apparatus, which is shown in Figs. 2 and 3, on this page, was designed and constructed to determine this value. It employs a scissors-type action, with two pivoted angles. The inner 1½-in. diameter bolt with washers, and the nut just slack, acts as a pivot; and the outer ¾-in. diameter bolt under test, is fitted with a sleeve for measuring the tension in the bolt with an extensometer. The washer on the latter bolt, between the two angles forming the "scissors," is welded to the angle on which the sleeve presses, and the washer under the bolt head is free to slide on the surface of the angle. The four bolt holes in the two angles are $1\frac{7}{32}$ in. in diameter; there is thus $\frac{1}{32}$ in. clearance for the pivot bolt, and a maximum movement of $1\frac{1}{32}$ in. is allowed for the bolt under test. Weights are applied to the end of the movable angle until it begins to fall, and the angle is provided with graduated markings to facilitate observation of the start of movement.

All parts were galvanised, and the rubbing surfaces were in a weathered state during the tests. They were found to have an average static coefficient of friction of 0·42. It is possible to obtain higher values if, for example, the surfaces are roughened, but the value determined for normal conditions is typical of structural practice. The frictional restraint exerted by a bolt is proportional to the tension in the bolt, the coefficient of friction, and the number of frictional contacts. For example, a 1-in. diameter mild-steel bolt has a cross-sectional area at the root of the thread of 0·554 sq. in. for Whitworth threads and 0·597 sq. in. for British Standard fine threads; allowing 9 tons per square inch tensile load (British Standard Specification No. 153, Part 3 (1937), page 20), the pull exerted by the bolt is 4·98 tons or 5·37 tons, respectively, and the frictional restraint is 2·1 or 2·25 tons, for single-contact friction. In a simple connection consisting of two plates joined by a bolt, there are two frictional contacts, i.e., between the plates, and between the bolt head and plate or nut and plate. In such a case, using the 1-in. bolt, the frictional restraint without bearing or shear would be 4·2 tons or 4·5 tons, respectively. Taking the bearing and shear stresses as 15 and 6·5 tons per square inch respectively (B.S.S. No. 153, pages 21 and 22), the diameter of the bolt as 1 in., and the thickness of the plate as t in., the allowable bearing capacity is thus $15t$ tons, and the allowable single-shear capacity is 5·1 tons. The relation, for bolts of different diameters, between double-contact frictional restraint, the shear capacity, and the bearing capacity, is shown in Fig. 4.

It will be observed that, if the allowable bearing capacity, $15t$, is to equal the double-contact frictional restraint exerted by a 1-in. bolt stressed to 9 tons per square inch in tension, then t must be equal to 4·2 divided by 15, which is approximately 0·28 in. In general, within the limitations of B.S.S. No. 153, the ratio of plate thickness to bolt diameter must be approximately 0·28, if the frictional restraint is to absorb the whole of the load on the connection, when it is stressed to a load equivalent to the allowable bearing capacity. This is indicated by the points marked by small circles and crosses in

Fig. 4. Furthermore, under the same conditions, the load on the joint approaches the allowable bolt shear stress. It follows, therefore, that if bolts are used which are more than three or four times the plate thickness in diameter, the frictional grip will exceed the maximum bearing capacity which would otherwise determine the strength of the connection.

It may be considered unnecessary to use such large bolts on plates over $\frac{3}{4}$ in. in thickness, but this practice is becoming more common. The author has confirmed the wisdom of it in many rapidly-assembled structures, particularly bridges. If the bolts are well tightened, bearing and shear are merely emergency safeguards, although they are each capable of taking the load independently of the friction. Such bolted connections are thus very effective in practice, even when overloaded. If, as sometimes happens in structural work, bolts are tightened after the load has been partly or wholly applied, the subsequent structural load may be divided between friction, bearing and shear stresses.

Large-bolt or high-frictional connections have been used in Callender-Hamilton bridges for many years, and a typical example is shown in Fig. 1, on page 433. The loading on these foot bridges, road bridges, and railway bridges, has varied considerably. They have carried some of the heaviest road traffic in England, as, for example, at the Westgate Bridge, Gloucester, which carries the main South Wales highway; the Southwark Bridge approach spans in London; and on the Great North Road. In Holland, they have been used as railway bridges carrying up to 120 trains a day.* The connections in Callender-Hamilton bridges range from single-lap joints to multi-plate butt joints, with bolts from $\frac{1}{2}$ in. to 2 in. in diameter, passing through plates from $\frac{1}{16}$ in. to $\frac{3}{4}$ in. in thickness. They comply with the usual design rules, but most of the bolts are of the large-diameter type. Experience with these bridges has shown that there is no appreciable movement of the connections after they have been tightened. As bolts removed for inspection rarely show any marking on the shanks, it is evident that such bridges, with spans from 20 ft. to 300 ft., are all held largely by friction induced by the bolts.

Considerable experience with bolted hangars, store-sheds and transmission towers has also confirmed these conclusions. The hangars and store-sheds are constructed of bolted lattice-portal trusses of box form, which are subject to severe, and often reversing, wind stresses, owing to the width of the roof spans. They are used in many parts of the world, but it is unusual to find slack bolts in them. When the first hangars of this type were constructed, tests were conducted at the works of Messrs. Painter Brothers, Limited, Hereford, on trial ribs designed for various loads and spans.† Provided the bolts were tightened adequately during construction, it was found that the structures behaved wholly elastically up to the limits of the design loads. When the load was increased beyond such a limit, a point was reached where several joints slipped simultaneously, and an audible shock wave shook the structure. With a further increase in the load, the deflection was again elastic up to the yield point of one or more of the members and complete failure of the rib. The plates and angles of these ribs are usually $\frac{1}{8}$ in. to $\frac{1}{4}$ in. in thickness; the bolt diameters are $\frac{5}{8}$ in. or $\frac{3}{4}$ in.; and the clearance of the bolt in the hole is usually $\frac{1}{16}$ in., but in some cases it is $\frac{1}{8}$ in. Bolted connections in many thousands of transmission towers throughout this country rarely require tightening, or act other than in a frictional manner when tested. As with the hangar ribs, thin galvanised structural sections, with comparatively large diameter bolts, are generally used. The bolt-hole clearance in these towers is nearly always $\frac{1}{16}$ in., but slipping is unusual at normal working loads. It is also interesting to note that bolts of about $\frac{1}{2}$-in. diameter are commonly used in aircraft for connecting plates and members $\frac{1}{16}$ in. thick; the bolts are of high-tensile steel, and consequently induce considerable frictional restraint.

* See ENGINEERING, vol. 163, page 1 (1947).
† *Ibid.*, vol. 146, page 727 (1938).

It is normal practice to deduct the area of metal removed to form a bolt hole, when calculating the load-bearing capacity of a member in tension. This is doubtless a wise and conservative rule, appropriate to a pin-type connection. When a fully-tightened large-diameter bolt is used, however, the strength of the member is not reduced as much as the rule implies. Such a bolt becomes, in part, elastically homogeneous with the member. It will be easier to appreciate this, if the parts are imagined to be made of rubber: when the plates are stretched the distortion will also be apparent in the bolt-head, nut and washer. The action of such a bolt may be compared to that of the jaws of a testing machine, holding the piece under test. It will be seen, therefore, that large bolts strengthen the members which they connect, and their usefulness is not confined to a pin-type action of the shanks.

The distribution of stress in a soundly-constructed bolted connection is favourable, and free from dangerous indeterminate secondary stresses and stress concentrations at the hole edges, etc. Until the joint is tightened, there is usually little primary stress in it, and no secondary stress. On application of the main load after tightening, there are the primary and secondary stresses due to the load, but none due to inaccuracies in the relative positions of the bolt holes, as would occur with rivets or force-fit bolts. If either primary or secondary stresses, or the resultants of these, become too high at any time, there will be some relief by slight local slipping, before failure can occur. As the load is increased, this adjustment of the stresses by slipping will continue until, finally, the shearing, bearing, and frictional capacities of the connection act together. In such a state, the load capacity of the bolted connection is considerable.

It is evident that where the load is taken largely by friction, and hardly at all by shear or bearing, the method of making the holes is not so important: punched, flame-cut, or badly drilled holes will not be as detrimental as they would be in connections depending on shear or bearing capacity. Tests have confirmed this, and although it is desirable to maintain a high standard of workmanship, it is evidently not vital for a friction-held joint. Even a slight bearing of the surface of the hole on the bolt thread is not likely to be harmful. A rivet, on cooling, also induces high frictional restraint, which may well be as effective as the similar action of a large-bolt connection, but as the maximum diameter of rivets is generally about $1\frac{1}{4}$ in., it is not possible to obtain a high-friction joint if the plates are much above $\frac{1}{2}$ in. in thickness. It is true that the number of rivets may be increased, but this is not always satisfactory. A further disadvantage of rivets is that it is possible for the shank of a hot rivet to be "joggled," if the holes in the plates are not accurately aligned. This, and burning of the rivets, are not readily detected in the field.

If bearing capacity were the only consideration, it would not be possible to increase the strength of a structure by using high-tensile bolts, because the allowable load would be limited by the strength of the mild-steel members; but if the frictional factor is accepted, high-tensile bolts may be used to provide increased bolt tension, and hence increased strength of the joints. Thus, the strength of a mild-steel structure may be increased at slight extra cost, because the proportion by weight of bolts to members is small (the weight of bolts, nuts and washers is usually about 10 per cent. of the total weight of the structure). For example, the strength might be increased by 10 per cent. for an increase of cost of 1 per cent.

High-friction connections are advantageous for members in tension—especially single-bolt end connections—but they are also useful for members in compression. The ends of the members are held more rigidly, and therefore higher crippling stresses can be resisted. When several bolts are used, the connection will withstand considerable rotative, as well as longitudinal, stresses. The old design rule specifying the deduction of half the free leg, in addition to the area of the hole or holes, is probably unnecessarily conservative, although tests to confirm this would be welcome. If, as a result of such tests, a more suitable design rule could be formulated, a considerable saving of steel might be achieved, since it is a common type of joint.

There has been much discussion on the quality of workmanship considered desirable in bolted connections. Some bridge and building rules state that, if bolts with $\frac{1}{16}$-in. clearance in the hole are used, the number should be 15 per cent. more than if rivets are used; turned tightly-fitting bolts are considered as equivalent to rivets in this respect. In the author's view, these rules are pessimistic for the bolts with clearance, and optimistic for the tight bolts if they have reduced thread diameter. For bridge and hangar work, the author has generally specified $\frac{1}{16}$ in. clearance, and the diameter of the threaded portion to be the same as that of the shank, to afford the maximum strength. Such bolts are simple to manufacture, and it is considered that the figure of 15 per cent. in the rule specifying the number of bolts may safely be reduced to $7\frac{1}{2}$ per cent. for bridge work, and abolished altogether for transmission towers. If a joint is secured by frictional restraint, there appears to be no reason why a black bolt should not be used, provided it conforms to an appropriate standard and fits readily in the hole. For high quality bridge work, it is often specified that the bolts shall have turned shanks (plus 0, minus $\frac{1}{64}$ in. on the nominal size), and turned surfaces under the bolt head and nut. Black bolts of sufficient accuracy, however, would appear to be equally suitable.

It has already been noted that the thread must be of the same diameter as the shank, if a bolt with maximum tensile strength is to be obtained. The Whitworth thread is generally employed, but there are advantages in using a British Standard fine thread. There is a greater cross-sectional area at the root of the thread, a greater tightening force for the same effort on the spanner, and less liability to slacken due to overload or insufficient tightening. More accurate cutting is required for fine threads, but modern machine tools provide for this. Rolled threads are also used extensively. Regarding the question, sometimes raised, whether threads of full bolt diameter are more liable to injury during assembly, the author has found that this is not a matter of any importance: threads are rarely damaged in this way and, in any case, a small percentage of spare bolts must be to hand to replace lost bolts. The older British Standard sizes for bolt heads and nuts, and those specified in British Standard Specification No. 916 (1946), are all satisfactory in strength, but the latter are lighter, they are more convenient for use in restricted positions, and are easier to forge. A series of tests to determine the ultimate tensile strength of high-tensile and mild-steel bolts and nuts, galvanised and ungalvanised, and with heads and nuts according to both specifications, showed that bolts with British Standard fine threads were 5 per cent. to 10 per cent. stronger than those with Whitworth threads; this also applied with the lighter type of nuts. It was found that galvanising had little appreciable influence on the strength.

For bolted structures, it is important to ensure that the size and position of all punched or drilled holes are accurately controlled in the shop. This provides interchangeability and avoids unnecessary work on the site. The author usually specifies that the holes shall be within $\frac{1}{64}$ in. of the position given on the drawing, and that the tolerance on the hole diameter, like that on the bolt diameter, shall be $\frac{1}{64}$ in. between the maximum and minimum allowable diameters. Projecting edges to the holes must, of course, be removed after drilling, and the taper which is inevitable with punched holes should be controlled. If the hole and bolt are to be galvanised, due allowance must be made for the thicknesses of the spelter films, so that the tolerances are preserved.

The assembly of a bolted structure leaves less to chance and the carelessness of an unskilled workman, than the assembly of a riveted or welded structure. Any error in assembly is readily observed, and is usually corrected without harm or difficulty. The only important problem which still arises in assembling bolted structures is to ensure that the bolts are tightened adequately, but not over-

strained. A method of determining the load in a bolt due to tightening the nut, and the appropriate coefficients of friction to be used, have been given by J. L. M. Morrison.* Although men with some experience usually tighten bolts by hand with reasonable accuracy, an appliance for controlling the torque is desirable. Pneumatic or other power tighteners save labour at the site. Slackening of bolts in service is unusual, but if it is liable to occur, or deliberate theft is feared, the nuts may be spot-welded to the bolt shanks, using a portable electric or oxy-acetylene apparatus. There are, of course, many types of lock-nuts which may be used, but in the author's view the plain bolt and nut, particularly with fine-pitch threads, is very reliable, and nut-locking devices need only be used in exceptional circumstances.

Bolted connections in structures are particularly advantageous in conjunction with galvanising. If the structure consists of a number of comparatively small parts joined by bolts, every surface of the work, except the threads of the nuts, receives a protective coating of zinc; in particular, the holes and the whole of the bolts are galvanised. In contrast to this, riveted sub-assemblies which are subsequently galvanised are not always fully protected; and even if all riveting is done after galvanising, some of the zinc is vaporised, and the rivets themselves are not galvanised. There are similar disadvantages with welded structures. Slight crevices associated with welding are liable to be attacked by the pickling acid, and are a source of danger to the structure in service. Complicated structures containing temperature stresses from welding are liable to distortion when subjected to the heat of the zinc bath. A simple component such as a channel, which bends slightly in the bath, is readily straightened, but the distortion of a complicated structure is difficult to correct and almost impossible to predict or prevent. There are other methods of applying protective coatings, zinc spraying, for example, but galvanising is generally preferred and is eminently satisfactory in conjunction with bolted connections. It should also be noted that, even without either painting or zinc coating, there is heavier and better protection with a large-bolt connection from the amount of overlapping metal, than with other methods of connection.

* See ENGINEERING, vol. 161, page 409 (1946).

LITERATURE.

High Frequency Measuring Techniques Using Transmission Lines. By E. N. PHILLIPS, W. G. STERNS, and N. J. GAMARA. John F. Rider Publisher, Incorporated, 404, Fourth-avenue, New York 16, U.S.A. [Price 1.50 dols.]

"AT the present time," remark the authors of this book in an introductory note, "the most convenient tool for measurement in the frequency spectrum about 100 megacycles per second is a shielded transmission line with a continual slot along its axial length. When properly equipped with a measuring scale along its length and an index to indicate the position of a probe which explores the field between the conductors, the equipment can be used to measure wave-length, impedance, velocity of propagation, electrical length, and attenuation in four-terminal networks." The description of techniques for determining these quantities is the aim and purpose of the book.

The slotted transmission system described is about 7 ft. in length and was built up in the laboratory of the Collins Radio Company, of Cedar Rapids, Iowa. Before this apparatus could be used for general measuring purposes, it was necessary to determine its characteristic factors with the greatest possible accuracy, and the procedure adopted is described in full detail, together with a complete statement of the numerical data and, step by step, the way in which the surge impedance $\mathbf{Z}_0$ and the "residual length" have been measured; these quantities are expressed in terms of the linear measurements in centimetres read off the scale. The wavelength of the standing waves obtained for these measurements was $\lambda = 200 \cdot 7$ cm., corresponding to a frequency of (very approximately) 150 megacycles per second; in this way, the value of the surge impedance was found to be 52 ohms. For the purposes of the measurements, the standard expression used is

$$\text{Input impedance} = \mathbf{Z}_0 \tanh (\gamma x + \mathbf{p}_2),$$

$$\text{where} \quad \tanh \mathbf{p}_2 = \frac{\mathbf{Z}_2}{\mathbf{Z}_0}$$

and $\mathbf{Z}_2$ is the load impedance. This expression was then translated into such a form that the numerical quantities measured by the pressure probe and by the scale measurement of the position of the probe could be directly inserted.

The measurement of a load impedance connected to the end of the slotted transmission line is fully described, with the numerical data, and a valuable and excellently reproduced diagram of a "Transmission Line Calculator" is included. Far more important in practice, however, are those conditions in which the load and the slot-measuring line are connected by a length of radio-frequency cable. These problems are illustrated by representative worked examples, special attention being given to the attenuation in circuits which are linked by radio-frequency cables. A useful list of references to recent publications on radio-frequency measurements is included. The book is particularly noteworthy for its liberal provision of comprehensive examples, with the calculations worked out in full thus affording good opportunities for interesting instructional work in universities and technical colleges. It is a convincing demonstration of the high quality and the thoroughness of the industrial research work at radio-frequencies which is now being done in America. An error may be noted in the first line of page 5, in which 229 is printed instead of 299.

Jet Propulsion Progress. By LESLIE E. NEVILLE and NATHANIEL F. SILSBEE. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York, 18, U.S.A. [Price 3.50 dols.]; and McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 21*s.*]

MR. LESLIE E. NEVILLE is a director of the Institute of Aeronautical Sciences in the United States, and Colonel Nathaniel F. Silsbee an officer of the Air Reserve. Their book is an historical outline of the international development of the gas turbine for aircraft propulsion, from the American point of view. It is not a text-book on the gas turbine and does not seek to expound theories of propulsion. It is rather the type of book that will whet the appetite of the mechanical engineer, and amuse him if he is one on whom Americanisms have that effect; but there is no lack of appreciation of the seriousness of the revolution brought about by jet propulsion in the military field. The first chapter, entitled "The Weapon Behind the Revolution," is introductory and starts from Newton's Third Law. Then comes an account of German developments, with descriptions of the Jumo 004 and BMW 003, and some information on the other items of the Nazi gas-turbine programme. The information is of the type gathered up by the Intelligence teams sent into Germany early in 1945, and contains the most interesting and most obvious engineering detail, though not the minute detail discovered by experts in the home laboratories in subsequent investigations. The BMW 003 section also includes a description of the gas-turbine activity of the Bayerische Motoren Werke A.G., who produced it. This chapter is called "How the Nazis Beat Us to It." and gives the impression that the Americans were more surprised, and learned much more from the Germans than did the British aero-engine experts.

There follows a chapter on the developments in this country. If the title, "The British Were Early, Too," be allowed to pass, the reader will find a very interesting and accurate account of the work of the Royal Aircraft Establishment, Power Jets, Limited, and the engine firms who were called in to work on gas-turbine projects during the war. The leading personalities are given their due and the genius of Air Commodore Whittle is fully recognised. There are engineering notes on the Rolls-Royce Nene, the Armstrong-Siddeley Python, the Metropolitan-Vickers F3, and the Bristol Theseus types, which savour rather of the catalogue; although the account of the origin of Power Jets, Limited, and its early adventures makes dramatic reading. To make the story complete, however, this chapter should include the corresponding history of the Engine Department of the R.A.E. and its turbine division; and something on its leadership by Griffith, Constant and Hawthorne; and of its switch to Power Jets and then back again to civil-service status as the National Gas Turbine Establishment under Dr. Roxbee Cox and Constant, where the good work still goes on. Though not detailed in the narrative, Griffith's contribution to progress, starting with his aerodynamic theory of turbine design in July, 1926, and leading up to the contra-rotating principle and the contra-flow engine is outstanding, and so was the inspiration that he passed on to his assistants.

Chapter 4 contains a 44-page account of the American work of the "hardware variety," written in the usual racy style of that land. It describes how the American Air Force and American industry did "pull a miracle" from the summer of 1941 onwards, rapidly making up leeway and bringing their immense resources to bear, both in research and in the development of the jet engine. Whittle's secret visits to the United States to help them, in 1942, read like a film script. It must be admitted that the Americans brought immense enthusiasm to the project, though it may resemble rather the enthusiasm of the salesman than a thirst for knowledge or determination to beat the foe; but there is no doubt of their subsequent success, and that it would have been to them that Britain must have turned for the mass production of jet aircraft had the German jet offensive with the Me262 and the He162 really got under way. In this story, the personalities (and their nicknames) are prominent; but there is a really useful description of the engineering details of the General Electric turbo-jets, the I. 16 and the I. 40.

A chapter on the United States Navy provides a reminder of the early prominence (in secret) of the Birmann turbine, and the development, under Navy funds, of the Westinghouse units. There is some interesting detail on the development of composite-engined naval aircraft, which programme was producing results as recently as last year; though the combination of a big piston engine in the nose and a jet turbine in the tail was never really accepted in this country. Whittle's calculations, made in 1943, on this type of naval machine, showed that it would meet ship-borne fighter specifications, then right out of the reach of aircraft with a single engine of either type, but were rightly laid aside so that all resources could be applied to the gas turbine.

The remaining three chapters of the work are comparatively brief and are entitled: "Big Boost from Government Research," "Tough Problems Still to be Whipped" and "New Horizons." These are rather sketchy, for a complete account would contravene secrecy requirements of "national defense." A point to be noticed is the importance given to higher gas temperatures, though there is no qualifying remark that the optimum has been exceeded already so far as fuel economy is concerned for the turbo jet. It is quite true to say, of course, that, the higher the gas temperature, the higher the efficiency of a turbo-propeller engine; but development to higher temperatures will not improve the economy of the turbo-jet, though it will lead to proportionate increases in specific output. The book concludes on the note that it is for the citizens of the United States to see that they keep the lead in jet propulsion by accepting the burden of cost in money, and to support the Government, the military and industry in their joint attack on the problems involved. Appended are a chronology of aircraft gas-turbine developments, a glossary of technical terms, a bibliography, and an index.

Engineering Organisation and Methods. By JAMES E. THOMPSON. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 4 dols.]; McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 24*s.*]

THIS is an age of forms, but most engineers probably regard them as sources of annoyance rather than a remedy for all troubles. Mr. James E. Thompson, however, is an American industrial consultant, who,

to judge from this book, regards engineering organisation and methods as being principally a matter of forms. Forms for every conceivable purpose connected with the routine of a large engineering works are illustrated; the opulent scale on which this is done may be judged from the fact that four whole pages are devoted to illustrations of a front cover, title page, blank list of contents, and blank text page for engineering reports. The procedure for handling these forms is described practically to the last detail, and it is obvious that the author really does believe in the kind of organisation which prescribes that there shall be one correct way only of performing the minutest transaction in an industrial concern. It may be wondered, however, if even those who are like-minded will really appreciate this book, or whether even they will grow impatient after a few chapters, preferring to create their own methods rather than to copy in such exactitude those of another.

The more technical problems at the basis of engineering organisation, such as cost analysis and production control, are only sketchily dealt with, and some of the author's statements seem to be positively retrograde. He says, for example: "In no case should the absolute maximum limits be specified for drawing dimensions," and recommends an allowance of 25 per cent. as a "cushion" to permit acceptance of many imperfectly manufactured parts. Of modern scientific methods of quality control, there is not one word in the book. There are appendices on cost procedure and analysis, consisting mainly of some simple comparative analyses of the cost of manufacture of a few elementary parts and a most detailed account of a system of code numbers for the cost items of an aircraft fuselage. The approach seems to be typical of a mental attitude, sometimes encountered, which delights in the manipulation of details for their own sake, and is comparatively uninterested in the broad problems of which they are a subsidiary part. Those who are concerned with such details—who, for instance, prepare requisition and similar forms for the printer—no doubt will find the book of some use, as the lettering of the illustrations is reasonably clear; but, of the book as a treatise on engineering organisation and methods, it can only be said the author fails to see the wood for the trees.

EXPERIMENTAL METHOD OF STRESS ANALYSIS.

By J. H. LAMBLE, M.Eng., Ph.D., M.I.Mech.E.

THE experimental study of the stress distribution in loaded machine parts or structural details has been extended considerably in recent years by the development of the Huggenberger, Johannsen and Tuckerman extensometers, the various types of electrical strain gauges, and the brittle lacquers known in the United States as "Stresscoat."

A simple approach which, with the exercise of a little care, will give accurate quantitative results may be made by the use of ordinary plumber's resin—the dark and impure variety. It will be recalled that the late Professor B. P. Haigh and his colleagues used this material on structural members to indicate yielding under load, this being shown by heavy cracking of the resin. A study of the local areas of yield and of the directions in which the cracks were spreading enabled improvements to be made in the design under examination. The cracks followed the general directions of the Lüders lines, well known in tensile testing.

At the Manchester College of Technology an intensive study is being made of the stress distribution in flat plates subjected to hydrostatic loading, the edges of the plates being constrained to remain in a plane. A series of stress values on the plate surface was obtained from deflection measurements and also from the use of Huggenberger extensometers, and these values were rather different from those obtained by earlier workers. It thus became necessary to find an additional means of checking the results, and for this purpose a modification and extension of Haigh's method to the elastic range was tried. The plate under examination was laid on a level wooden bench and coated with a uniform layer of finely powdered resin. This was melted by radiant heat from an electric fire, the fire being withdrawn after the coating had flowed into a layer of uniform thickness so that the plate slowly cooled to room temperature. The plate was then transferred to the supporting apparatus, care being taken not to cause any cracking of the resin coat. Hydrostatic loading was then applied until the crack pattern shown in Fig. 1 developed. The cracks were photographed after removal of the plate from the apparatus, the camera being above and to one side of the plate in order to obtain good definition of the cracks in the photograph. It is considered that the use of a dye, as with "Stresscoat," would enable the plate to be photographed from directly above it.

Fig. 1 is for a 24-in. by 16 in. by $\frac{1}{4}$-in. Duralumin plate with the surface "as rolled," this being indicated by the dark areas in the photograph. Fig. 2 is for an Elektron plate of the same dimensions, one quarter only being shown, and in this plate the surface had been prepared in the manner used for zinc plates in making blocks for printing. This produced a uniform mat surface leading to easier photography, but was not really necessary. In general, the cracks show the directions of the principal stresses at any point; the minor principal stress acts along the crack and the major (tensile) at right angles to it. A calibration strip was prepared and strained as a simple cantilever. It was observed that cracks appeared at about 0·00005 strain, which corresponds to a stress of 0·4 ton per square inch for the Duralumin plate. The crack pattern with associated loading confirmed the previous stress measurements. The two photographs from which Figs. 1 and 2 have been reproduced were taken by Mr. G. L. Wakefield, A.I.B.P., F.R.P.S.

The method is cheap and convenient in use and does not require the use of elaborate apparatus. For heavy sections the material might be heated with an oxy-acetylene torch and the resin applied by rubbing the hot surface with a large lump; experiments have shown that the use of a solvent is inadvisable. The resin coating appears to be insensitive to reasonable atmospheric variations and so may be used out of doors without any special precautions.

METHOD OF STRESS ANALYSIS.

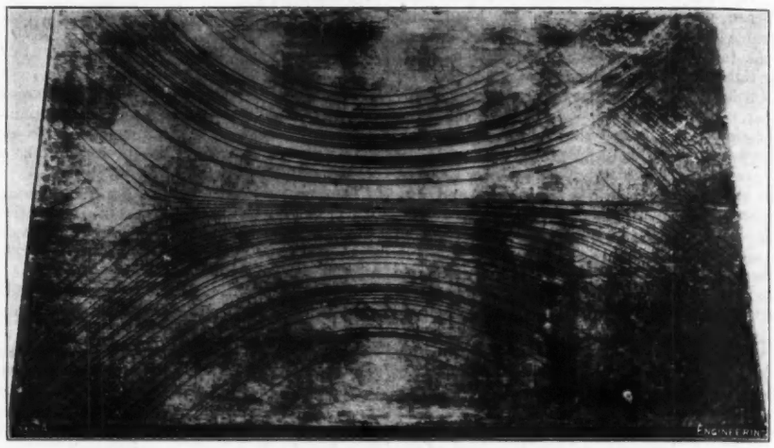


FIG. 1.

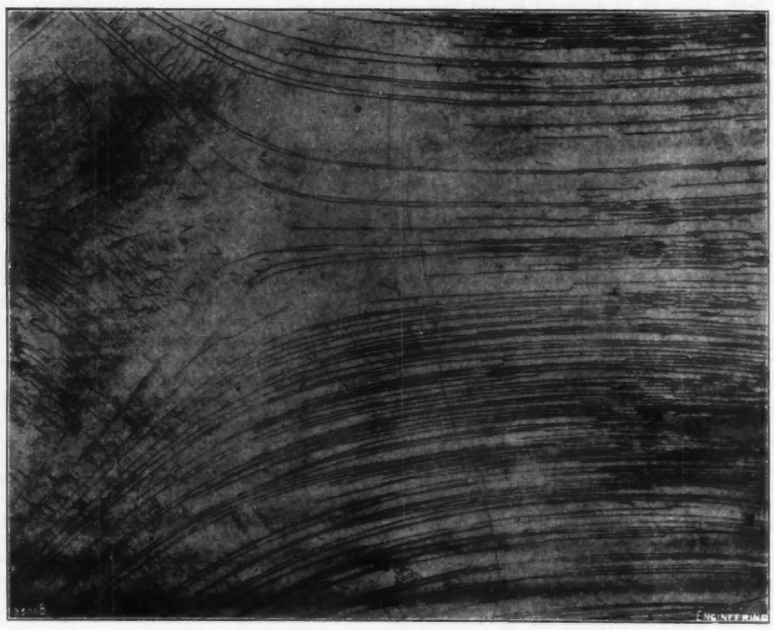


FIG. 2.

EXHIBITS AT THE BRITISH INDUSTRIES FAIR.

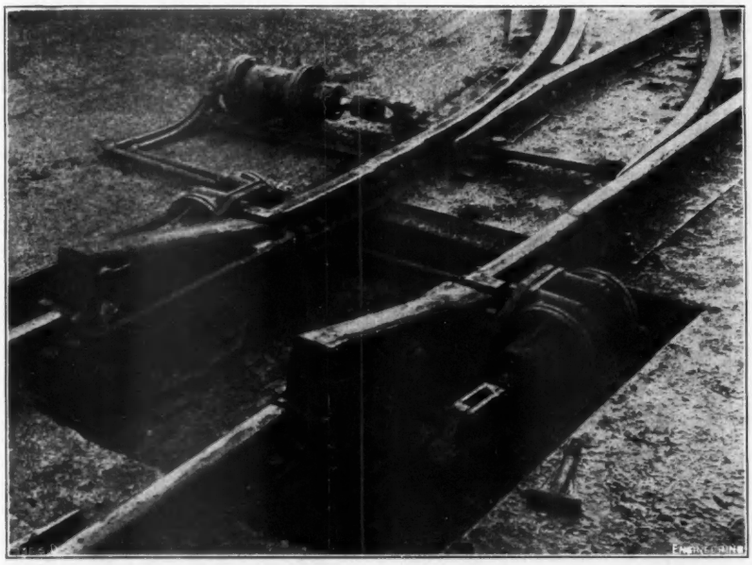


FIG. 1. SCOTCH BLOCKS FOR AUTOMATIC DECKING PLANT; WESTINGHOUSE BRAKE AND SIGNAL COMPANY, LIMITED.

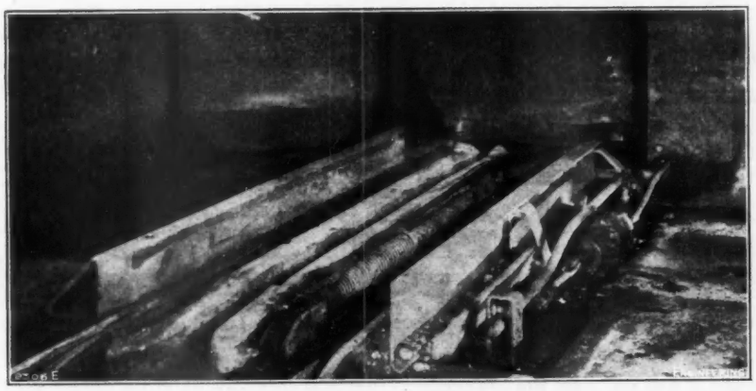


FIG. 2. TUB RETARDER FOR AUTOMATIC DECKING PLANT; WESTINGHOUSE BRAKE AND SIGNAL COMPANY, LIMITED.

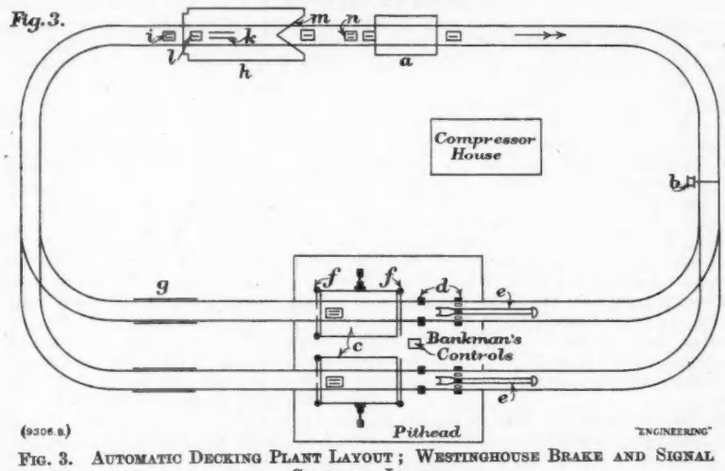


FIG. 3. AUTOMATIC DECKING PLANT LAYOUT; WESTINGHOUSE BRAKE AND SIGNAL COMPANY, LIMITED.

BRITISH COAL UTILISATION RESEARCH ASSOCIATION.—The first number of an official organ of the British Coal Utilisation Research Association, entitled the *B.C.U.R.A. Quarterly Gazette*, has been issued recently. It contains an article by the President of the Association, Sir Charles Ellis, F.R.S., on the activities in 1947, descriptions of furnaces, domestic-heating appliances and other equipment patented by the Association, and a section devoted to personal and other news items. The circulation of the new publication, it is stated, will not be restricted to members of the Association, and persons interested should communicate with the Development Division of the Association, 13, Grosvenor-gardens, London, S.W.1.

THE BRITISH INDUSTRIES FAIR.

THE British Industries Fair opened on Monday, May 3, and will remain open until Friday, May 14. As usual, it is being held simultaneously at Olympia and Earl's Court, in London, and at Castle Bromwich, near Birmingham. About 1,000,000 sq. ft. are available in the three Fair buildings, and it is stated that many more applications for space were received than could be entertained. As usual, radio, scientific and optical apparatus are the chief items of technical interest to be found at Olympia. Earls' Court is devoted almost entirely to such trades as clothing, foodstuffs and furniture. Heavy engineering equipment, as in previous years, is concentrated at Castle Bromwich where, we are officially informed, 435 firms are exhibiting in this group. In addition, there are 223 firms in the electricity group, and these two sections between them occupy a large proportion of the 400,000 sq. ft. available. The latter figure represents an increase of some 90,000 sq. ft. over last year, when for the first time the Fair was held in May instead of in February.

A general impression of the Fair at Castle Bromwich is that, as in previous years, there tends to be a predominance of products associated with the Birmingham area. Few heavy-engineering firms have taken space, with the result that concerns making hardware and raw and semi-manufactured products are likely to attract a large proportion of the visitors' attention. Mechanical engineering, however, is adequately represented, especially in so far as certain branches of the machine-tool industry are concerned. Electrical firms have concentrated on displays either of domestic equipment, radio sets or electronic devices, and illumination.

On page 608 of our 164th volume we gave a description of an automatic decking plant for coal tubs, which had been installed at the Bold Pit, St. Helens, by the Westinghouse Brake and Signal Company, Limited, 82, York-way, London, N.1. The possibilities of utilising equipment of this kind for a variety of purposes is illustrated at Castle Bromwich by the firm's exhibit which covers 3,000 sq. ft. of the outdoor section of the Fair and is arranged to represent a pit bank complete with headgear. The layout of this exhibit is shown diagrammatically in Fig. 3, the hoist, at which the cycle of tub movements begins, being indicated at *a*. This hoist is at the highest point of the system and from it empty tubs run by gravity along a single track and over an axle counter. This counter, *b*, controls the supply of air to a cylinder, thus operating the points at the entrance to the double tracks which lead to the cages *c* at the top of the shaft. The points are switched over from one track to another automatically when a predetermined number of tubs have passed over the counter.

Just before reaching each cage, the tubs are stopped and held by the scotch blocks *d*, which adjoin the control station for the whole system. A view of this equipment is given in Fig. 1. (At an actual pit top the tubs would remain at this point until the appropriate cage had arrived at the landing with a load of full tubs.) The gates at each end of the landings are then opened automatically and the group of waiting empty tubs is pushed forward into the cage by pneumatic rams, *e*, placed between the rails. The full tubs are pushed out by the empty tubs and run on to the tracks on the opposite side of the cage. The pneumatic decking ram on the cage is fitted with a spring-operated link, which automatically engages with the last axle on the group of empty tubs when it is retracted. A controller at the exit of the cages then ensures that the pre-determined number of full tubs pass out before the first empty tub is stopped.

On leaving the cage, the full tubs descend a gradient and are slowed down by automatic air-operated retarders *g* before entering the single-track section. A typical retarder, such as is used for this purpose, is illustrated in Fig. 2. As will be seen from Fig. 3, the single track leads into an automatic airlock, *h*. On an actual installation, one of these locks would be placed on each side of the pit-head gear as was done at the Bold Colliery, but at Castle Bromwich it has been built separately, in order to

allow easy access for inspection. As they approach the airlock the tubs pass over an axle counting controller *i* and on to the stop *k* in the lock. When a pre-determined number of tubs have been admitted, lifting doors at the entrance to the airlock are automatically closed and locked. Swing doors *m* at the exit of the airlock then open and the tubs run out to a controller *n*, which is situated on a parking section of line leading to the hoist *a*. The tubs are elevated by this hoist to the top of the gradient and are subsequently released to recommence their working cycle. Air for the operation of all the pneumatic plant connected with this exhibit is generated on site by compressors of the Company's standard type.

A machine for testing gear materials and lubricants is shown on the stand of Messrs. David Brown and Sons (Huddersfield), Limited, Huddersfield. It has been designed to simulate the effect of mating gears: the peripheries of two discs are rubbed together by rotating them at different speeds, and the pressure between them can be varied at will. A testing machine of this type was described in a paper* by Dr. H. E. Merritt, M.B.E., before the Institution of Mechanical Engineers, in 1935. The latest machine is to an improved design; in particular, self-aligning bearings have been used. Fig. 4 is a general view of the machine, and the arrangement of the principal parts is shown diagrammatically in Fig. 5. Mounted on a pivot *a*, on each side of the machine housing, is an arm *b*, which carries a self-aligning bearing *c* at its lower end. The two bearings support a disc *d*, which is therefore free to rotate, and also to swing about the pivots *a*. A motor-driven disc *e*, the axis of which is fixed, is also mounted in the housing. The periphery of the movable disc *d* is thrust against that of the other disc by a pair of adjustable struts *f*, which, in turn, are pushed by the bell-crank action of the pair of levers *g*, pivoted about the pin *h*. The thrust is varied by moving a jockey-weight *i* along the levers. The weight is supported on a carrier *j*, on the underside of which there are two balls engaging in "dimples" drilled in the upper surface of the levers. The machine is driven by a trunnion-mounted motor through reduction gearing, the motor being arranged for measuring the torque with a spring balance. The drive from disc *e* to disc *d* may be either through gearing or through a chain and sprockets. The latter method provides the most severe test, because the rubbing surfaces are moving in opposite directions. The manufacturers have called the machine the "self-aligning disc machine." It can be used either with a standard lubricant to test the load capacity or the coefficient of friction of any particular combination of materials; or with a "standard" combination of materials to test a lubricant. Two discs made of 4½ per cent. nickel-chromium steel, heat treated to a tensile strength of 100 tons per square inch, provide the standard combination of materials for simulating spur, helical and bevel gears; and one disc of centrifugally-cast phosphor bronze and another of 2 per cent. nickel-molybdenum case-hardened steel represent typical worm-gear conditions. The lubricant adopted as the standard for the material tests is a good quality straight mineral oil with a viscosity of 410 Redwood seconds at 140 deg. F. The surface finish of the rotating discs is an important factor. The peripheries are therefore finished by fine grinding, followed in some cases by honing, to produce surface finishes within a clearly-defined range.

When the plant of Messrs. Manchester Oil Refinery, Limited, 10, Dover-street, London, W.1, was brought into operation in 1938, trouble was experienced with the high-pressure pumps used for handling liquid sulphur dioxide and benzine mixtures. Some mechanical seals were therefore developed for this duty, and the firm of Messrs. Flexibox, Limited, Twining-road, Trafford Park, Manchester, an associated company, was formed to manufacture the seals. They are made in a wide range of sizes for refrigeration compressors, chemical process pumps, oil process pumps, food pumps and mixers, etc. The principal parts of two seals are shown in Fig. 6, opposite, and a longitudinal section is reproduced in Fig. 7. A compounded-carbon ring *a* fits into two synthetic-rubber rings in a cover *b*, in which it is prevented from turning by a peg *c* fitted in a slot. A ring *d*, of die-cast iron or stainless steel, bears against the carbon ring, the joint forming the rotary seal. The ring *d* floats on a sleeve *e* by means of a synthetic-rubber ring. A similar ring is also interposed between the sleeve and the shaft. A helical spring *f* is compressed between a shoulder on the sleeve and the ring *d*. It will be seen from the section that the design allows considerable flexibility, and the proper mating of the two rings is thereby assured. In the range of seals supplied for oil-refining purposes, several modifications can be incorporated. It is sometimes desirable to circulate the liquid around the sealing faces, particularly in pumps used for very hot or cold liquids, and a cover provided with holes for this purpose is shown in Fig. 7. If liquids with poor lubricating properties are being pumped, a lubricant may be fed in through a hole in the cover and the carbon bush, as shown in Fig. 7. An auxiliary packing and gland is also shown in the cross-section; this is sometimes necessary for particularly arduous conditions.

The principal exhibit on the stand of the Brush Electrical Engineering Company, Limited, Loughborough, is the steam end of a turbo-generator. This is shown with the upper half of the turbine casing removed but with the rotor in position to display the interior. The exhibit is complete with steam chest and all controls, although the alternator and the intermediate gearing have been omitted. This machine is interesting from the fact that it is the first of the axial-flow type to be constructed by the firm. It has been designed to meet the requirements of industries which use process steam. A typical rotor is illustrated in Fig. 8, on page 444, but all the machines in this range, whatever their size, are of similar design and will be constructed so that their length can be adjusted to accommodate the number of stages required for any steam conditions.

To achieve maximum efficiency, blades of vortex design are used. The mean diameter of the blading has been kept small, so that the blades are relatively long in relation to the quantity of steam to be passed. It is claimed that for this reason it is possible to make a turbine with a small output, the efficiency of which is not much less than that obtainable with larger units. The set exhibited, of which the rotor illustrated forms part, is designed for outputs up to 3,500 kW when supplied with steam at 400 lb. per square inch, the back pressure being about 15 lb. per square inch. Given these conditions, nine stages are used, the speed being 10,000 r.p.m. Nevertheless, owing to the small diameter of the unit the blade speed is no higher than has been customary for some years. The small size and compactness of the unit also enable it to be mounted on a three-point support, so that while it is rigidly held it is completely free to expand. The range of output of these back-pressure turbines and of the pass-out and straight condensing sets, which have also been evolved on the same principles, ranges from 600 to 6,000 kW.

A comprehensive range of instruments for both engineering and marine purposes is being shown by Messrs. Smiths Industrial Instruments, Limited, Cricklewood Works, London, N.W.2. The exhibits include the hand tachometer illustrated in Fig. 9, on page 444, which is manufactured by Messrs.

* *Proc. I.Mech.E.*, vol 129, page 127 (1935).

EXHIBITS AT THE BRITISH INDUSTRIES FAIR.

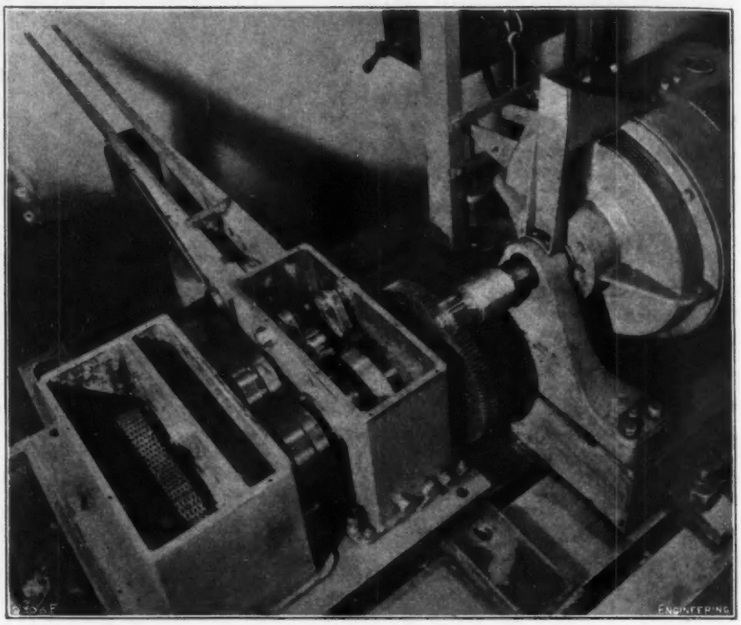
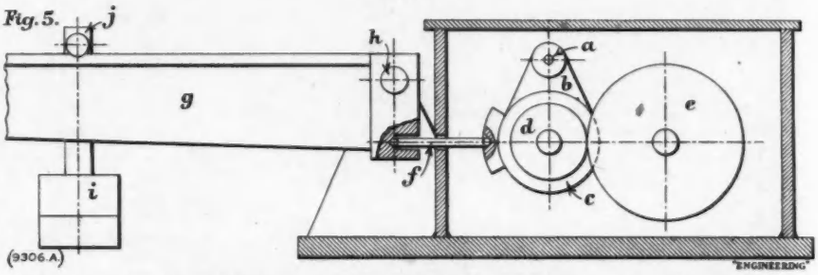


FIG. 4.

Fig. 5.



FIGS. 4 AND 5. TESTING MACHINE FOR GEAR MATERIALS AND LUBRICANTS; MESSRS. DAVID BROWN AND SONS (HUDDERSFIELD), LIMITED.

EXHIBITS AT THE BRITISH INDUSTRIES FAIR.

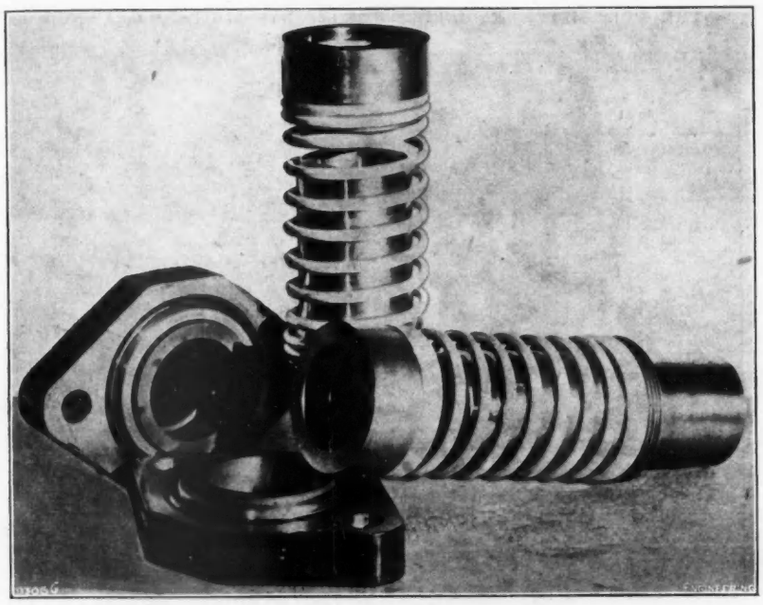
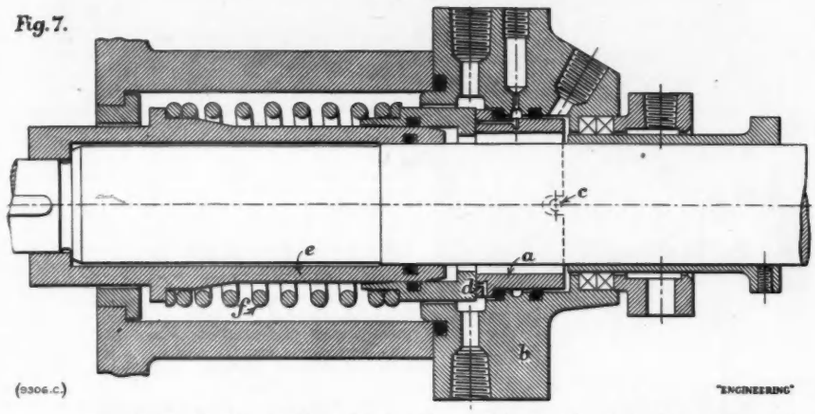


FIG. 6.

Fig. 7.



FIGS. 6 AND 7. CARBON-RING LIQUID SEALS: MESSRS. FLEXIBOX, LIMITED.

A.T. Instruments, Limited, a subsidiary of Smiths Industrial Instruments. The design of the tachometer is based on the A.T. speedometer, which was illustrated and described in ENGINEERING, vol. 160, page 186 (1945), the mechanism comprising a rotating permanent magnet which produces eddy currents in an aluminium-alloy drum. The pointer is fitted to this drum and the drum assembly moves within jewelled bearings, the necessary restraint being provided by a hairspring. Unidirectional rotation of the magnet is ensured by an idler gear and rocking lever incorporated within the drive. The casing is a light-alloy die-casting, which also forms the chassis of the instrument. As will be seen from the illustration, the complete unit is of compact design and convenient to handle. A speed range of 0 to 50,000 r.p.m. is provided by a gearbox incorporated within the casing, the indicating ranges being 0 to 500 r.p.m., 0 to 5,000 r.p.m. and 0 to 50,000 r.p.m., respectively. These ranges are selected by the knurled knob visible in the illustration. In order that the instrument may be used in inaccessible positions, a push-button control is provided which locks the indicating pointer while running, the pointer being returned to zero by the depression of a second push button, which is fitted to the opposite side of the instrument. The driving spindle has a hardened square end for use as a driving centre at low speeds and, in addition to the usual detachable rubber centres, a disc is supplied for the measurement of surface speeds. Two other designs are available which are similar in all respects to that described but are provided with alternative speed ranges, namely, 0 to 10,000 r.p.m. and 0 to 20,000 r.p.m., the intermediate speed range being 0 to 2,000 r.p.m.

British Insulated Callender's Cables, Limited, Norfolk House, Norfolk-street, London, W.C.2, are exhibiting a number of electric welders of various types. Among these mention may be made of the 30 kVA bench-type flash welder, an illustration of which appears in Fig. 10, on page 444. This has been designed for welding steel strips, such as band saws, and its standard clamps (which are fitted with alignment guides) are arranged to take strip up to a maximum width of 3 in. Other types of clamp, however, can be fitted to make it suitable for almost any type of flash welding within its capacity. The base of this machine consists of a cast-iron plate, which carries all the operating gear and provides a bed for the transformer and contactor, the welder proper being supported on a fabricated frame. The right-hand clamp, which is carried on a cast-iron saddle, is operated by a cam, which is actuated by a lever. It is pointed out that this cam is designed so that consistent welds can be produced by an operator with very little practice. It is also arranged so that when the lever is moved behind the normal starting position the gap between the clamps is increased to a width suitable for normalising the smaller sections. The primary winding of the transformer is tapped so that four secondary voltages can be obtained. The last of these is specially low so that it can be employed for normalising. The welding current is controlled by a magnetic contactor. This is mounted inside the sheet-metal case, but is easily accessible for maintenance. It is closed by depressing a push button, which is mounted on the cover plate of the machine, and is opened automatically on completion of the weld by a limit switch, which is operated by a saddle. This welder has a range from 1 in. by 0·015 in. to 3 in. by 0·064 in. in mild or medium-carbon steels. The maximum secondary current is 7,500 amperes and the upset pressure about 1,000 lb. It is compact, being 24 in. by 15 in. by 20 in. high, and weighs about 2 cwt.

A general-purpose welder with a rating of 20 kVA for welding mild steel up to $\frac{3}{8}$ in. added thickness or aluminium up to $\frac{1}{2}$ in. added thickness, and three types of electric-resistance welders are also on view. Other exhibits include distribution boxes of various patterns, a straight joint for a three-core 33-kV screened type cable and runs of "Sandwich" type cables. The latter are claimed to be the most suitable type for industrial use where high ambient temperatures and vertical runs are encountered, owing to their "non-bleeding" qualities.

The exhibits most likely to attract attention on the stand of Messrs. Johnson and Phillips, Limited, Charlton, London, S.E.7, are the specimens of aluminium-sheathed electric cables, which this company are about to place on the market. Some details of these cables were given on page 404, *ante*, but it may be recalled that the use of this metal, instead of the more usual lead, for sheathing enables a reduction of weight of from 25 to 60 per cent. to be obtained with unarmoured, and of 20 to 35 per cent. with armoured, cables. Owing to its greater toughness and strength, aluminium-sheathed cable is, of course, more rigid than lead and doubt has sometimes been expressed as to its ability to withstand bending without damage. The opportunity has therefore been taken at the Fair to exhibit lengths coiled on drums to show that when aluminium-sheathed cables are used no increase in drum diameters over those employed with lead-sheathed cables is necessary. A large number of bending tests have also been carried out on various sizes of cables in accordance with the procedure laid down in the current British Standard Specifications, and Fig. 12, on page 444, illustrates three cables of similar size after undergoing these tests. In this illustration, the upper cable is aluminium-sheathed while the other two are sheathed with lead and lead alloy, respectively. It will be seen that there has been a very slight disturbance of the aluminium sheath, and the insulation was found, if anything, to have been less distorted than that of the lead-sheathed cable.

Another justifiable objection to the use of aluminium for sheathing cables is the difficulty of making soldered joints or sweated unions with that metal. Where plumbing is not required, however, aluminium is as suitable as lead provided that the necessary precautions are taken, including the employment of aluminium bushes to prevent contact between the sheath and other metals. Fig. 11, on page 444, shows an underground joint of this type, in which connection is made between an aluminium-sheathed and a standard lead-covered cable. For totally-sealed joints or terminations, a mechanical type of union has been developed to replace the normal plumbing gland. This union, which can be readily adapted to existing joint boxes and sealing ends, consists of a fitting comprising a pair of clamping rings between which the sheath, suitably belled, is gripped. This union replaces the plumbed joint. The only contact between the aluminium sheath and other metal is at the clamping rings, the faces of which are coated with cadmium to exclude any risk of galvanic action. The construction of a straight-through joint made in this way is illustrated in Fig. 13, on page 444. The end fittings mentioned above are applied and a sleeve of lead or tinned copper is passed over and plumbed to them in the ordinary way. The sleeve thus entirely encloses all the mechanical fittings and, in accordance with standard practice, the completed joint is enclosed in a concrete or metal box filled with compound to protect it from moisture.

(To be continued.)

LABORATORY VACUUM PUMPS.

To be effective, vacuum pumps of the mechanical type for laboratory use have to be sealed by oil and should therefore be provided with an automatic lubrication and sealing system; arrangements must be made also for drawing off unused oil for cleaning and removal of moisture if it becomes contaminated. The Pulsometer Engineering Company, Limited, Nine Elm Iron Works, Reading, manufacture pumps of this type, known as Geryk pumps, and particulars of a bench model and a small portable model are given below. The former, designated 4 S.T.1, is based on the design of the firm's rotary oil-sealed vacuum pump which is successfully used in connection with the manufacture of radio valves and electric lamps; and the small portable pump, the 1 in. F.R., has been introduced to meet the demand for a pump which could be moved about a laboratory conveniently.

For convenience in use, the 4 S.T.1 pump is not completely immersed in oil, but effective lubrication and sealing arrangements are provided. A photograph of the pump is reproduced in Fig. 1, on this page, and longitudinal and transverse sections through it are shown in Figs. 2 and 3, respectively. The cylinder is of close-grained cast iron, and the bore is 3⅜-in. in diameter. The rotor, which runs in line contact with the top of the cylinder, is of die-cast iron, and carries two sliding vanes, held apart by springs, in a ground slot. Discharge is through a spring-loaded disc-type valve which closes on to a renewable seat. The valve is covered by oil from an oil well, which is fixed on top of the cylinder. The rotor is lubricated by oil fed through the external pipe shown in Fig. 3, and returned through the discharge valve.

A stub shaft formed on one end of the rotor runs in a plain bearing in a cylinder cover, and a shaft on the other end also runs in a bearing in a cover, and is provided with a pulley. In order to prevent distortion of the rotor, or overloading of the bearing at the pulley end of the shaft, either of which would affect the line contact of the rotor in the cylinder, the pulley rotates on a trunnion extension which takes the thrust of the driving belt. This bearing is lubricated by a grease-cup lubricator, which is not shown in the illustrations. It is, of course, necessary to prevent air leaking through the bearing, and a rotary seal, which absorbs less power than a conventional stuffing box, is fitted for this purpose. The seal consists of two hardened, ground and lapped steel cups, which are separated by a helical spring, one being pressed against a face on the cylinder cover, and the other against a face on an oil-seal cover plate. Interposed between the spring and each cup is a square-section rubber ring backed by a steel follower ring, the rubber rings being a tight fit on the shaft and in the cups. The whole seal assembly rotates with the shaft, and the annular space is filled with oil from the well; this oil, in addition to lubricating and sealing the cup faces, causes the rubber rings to stick to the shaft. It will be seen that the cylinder covers are not provided with spigots; this is to enable them to be raised when, the rotor and cylinder having become worn, the cylinder is re-ground. By this means, the line contact between the rotor and the cylinder is maintained.

The circulation of oil is automatic, a small quantity being admitted into the cylinder immediately after each vane passes the oil inlet, when the pressure in the cylinder is momentarily not more than that of the atmosphere, and excess oil is discharged with the air which passes through the discharge valve and bubbles up through the oil in the well. A useful feature is that oil will not flow from the pump to the apparatus which is being evacuated in the event of the pump being stopped before it has been isolated. In the laboratory, it is often impossible to prevent moisture and condensable vapours from passing into the pump and contaminating the oil. To avoid any difficulty due to this cause, the 4 S.T.1, and other pumps in the Geryk range, can be fitted with drip-feed lubrication; the pump illustrated in Fig. 1 is provided with such an arrangement. Oil for lubrication and sealing is fed to the cylinder from an externally-mounted tank, and is collected for cleaning and removal of moisture from an overflow in the oil well. By opening and closing the several cocks, either system of lubrication can be employed.

The pump is designed to run at 600 r.p.m., and has a swept volume of 4 cub. ft. per minute. It is tested on a closed and dry circuit to a vacuum that is within 0·01 mm. of mercury of a perfect vacuum. The maximum horse-power absorbed by the pump under these conditions is 0·25. The time taken to evacuate a volume of 7 litres to the same vacuum is approximately 20 seconds. The discharge may be used occasionally for providing moderate pressures, but the pump would become overheated if used continuously in this manner. Fig. 2 shows the pump fitted with a pulley for a Tex rope, but pulleys suitable for a flat-belt or round-belt drive, as shown in detail, can be provided.

The 1 in. F.R. pump, to which reference has already been made, is designed on the same principle as that of the 4 S.T.1 pump, but it is smaller, and is mounted directly on one end of a ½-h.p. electric motor which runs at 1,425 r.p.m. The whole unit weighs only 45 lb., and, since it is almost entirely free from vibration, it may be run on a table, or elsewhere, without being bolted down. The rotor spindle is connected to the motor shaft by a flexible rubber sleeve, and to facilitate adjustment for wear the covers are not spigoted. The pump can be stripped, cleaned, and re-assembled in a few minutes without using special tools. The swept volume is 1 cub. ft. per minute, and the pump will evacuate a volume of 7 litres to within 0·1 mm. of a perfect vacuum in approximately 70 seconds. In the designation 1 in. F.R., 1 in. indicates the length of the cylinder, and F.R. means fast running. The speed of the pump is comparatively high, but as the cylinder is only 2 in. in diameter the peripheral speed of the vanes is not excessive.

LABORATORY VACUUM PUMP.

THE PULSOMETER ENGINEERING COMPANY, LIMITED, READING.

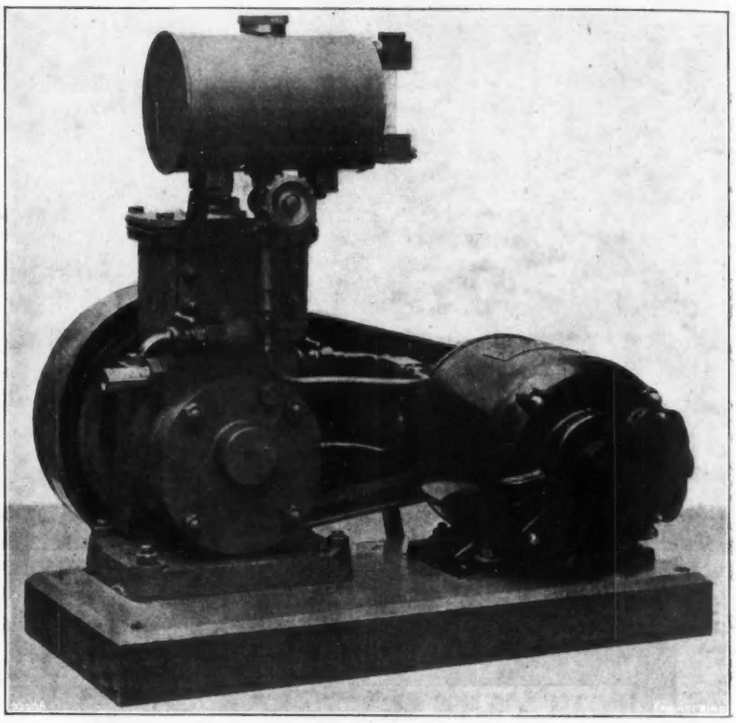
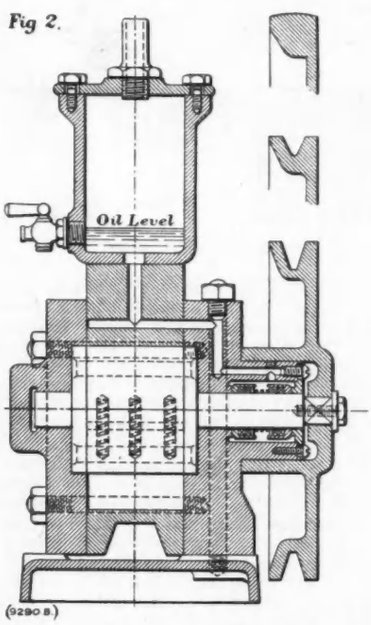


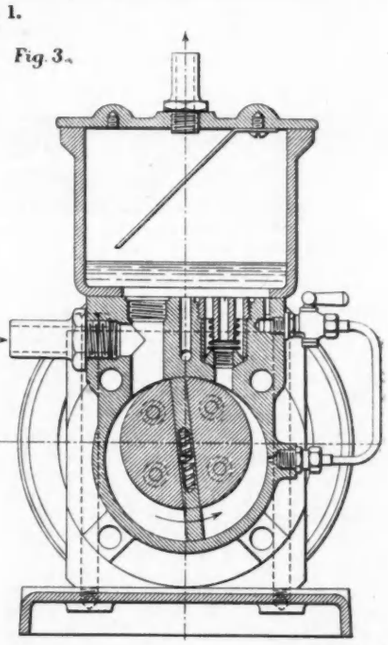
FIG. 1.

Fig. 2.



(9290 s.)

Fig. 3.



"ENGINEERING"

DOVER-BOULOGNE FERRY.—The Railway Executive and the French State Railways have under consideration a scheme for the construction of an additional train-ferry dock at Dover and a new dock at Boulogne, and the provision of two train-ferry vessels. This would supplement the present service between Dover and Dunkirk.

HYDRAULIC TESTING PRESS WITH PRE-STRESSED CONCRETE FRAME.

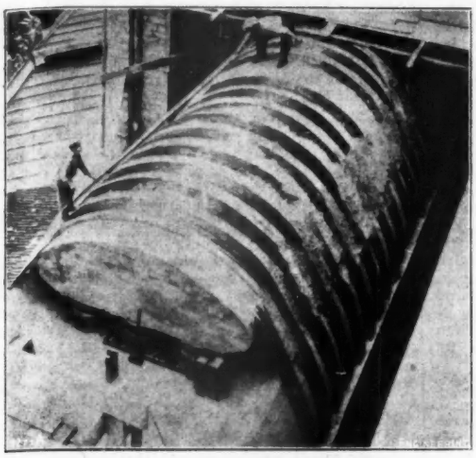
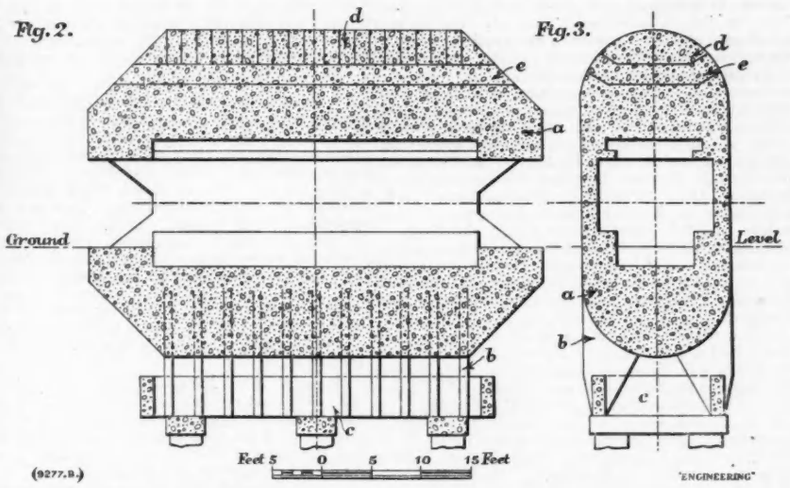


FIG. 1. VERTICAL PRE-STRESSING.



HYDRAULIC TESTING PRESS WITH PRE-STRESSED CONCRETE FRAME.

A 10,000-ton hydraulic testing press, the frame of which is constructed of pre-stressed concrete, has been in use for about 12 years at the Building and Public Works Laboratory in Paris (Laboratoires du Bâtiment et des Travaux Publics, 12, Rue Brancion, Paris, 15e). During construction, horizontal and vertical compressive stresses were set up in the frame by wire bands which were stretched by hydraulic jacks and subsequently grouted with concrete. The total weight of the press is about 700 tons. A view taken during the pre-stressing stage of construction is reproduced in Fig. 1; Figs. 2 and 3 are longitudinal and transverse sections, respectively, and Fig. 4 shows one end of the completed press.

In vertical and horizontal cross-sections the press is rectangular with semi-circular ends. The testing chamber is 11 ft. 6 in. square in cross-section, and, open at both ends. It contains hydraulic jacks, beams, a pedestal, etc., for applying compressive loads, and recording apparatus. The concrete frame is approximately 46 ft. in length and 15 ft. wide, and, as Figs. 2, 3 and 4 show, the floor of the testing chamber is at ground level. The body, *a*, is only lightly reinforced internally and 22 webs, *b*, are formed between it and a rectangular frame, *c*, which, in turn, is supported on six concrete foundations arranged in pairs transversely. Vertical pre-stressing was obtained by stretching 20 bands of steel wire, as shown in Fig. 1. The wires are of high-tensile steel of 56 tons per square inch elastic limit, and 73·5 tons per square inch ultimate tensile strength. Each belt contains 64 wires, 10 mm. (0·4 in.) in diameter, and is stretched over a concrete block, *d* (Figs. 2 and 3). During construction, the wires were passed around the frame and joined by welding the ends underneath. One band of wires was stretched at a time. Three 300-ton hydraulic jacks were placed between the block and the top of the body. The centre jack was pumped up to exert a force of 200 tons. Each of the two outer jacks was then pumped up to exert a force of 300 tons, and the centre jack was removed. Concrete was then packed between the block and the top of the body, leaving just sufficient space to remove the jacks after the concrete had set, after which the filling of concrete was completed. This process was repeated for the remaining 19 belts.

It was estimated that, due to compression of the concrete filling after removing the jacks, a loss of tension of 50 tons to 100 tons would occur. Each belt would therefore exert a force of at least 500 tons, and the total vertical force on the concrete body would be $20 \times 500 = 10{,}000$ tons. A similar method was used for pre-stressing in the horizontal plane. Five belts of steel wire were used: three around the body above the testing chamber, and two below the testing chamber; the force exerted by each horizontal belt was also estimated to be 500 tons. (The construction for the horizontal belts is not shown in the illustrations, but it does not differ, in principle, from that used for the vertical belts). The walls on each side of the testing chamber are approximately 33 ft. in length and 1 ft. 6 in. thick; the vertical stress is therefore about 1,600 lb. per square inch. The stress induced by the horizontal bands is also about this value.

When using the press for compressive tests, the specimen is placed between one or more jacks suspended from the roof of the testing chamber, and a cast-steel pedestal which rests on the sunken floor of the chamber. For deflection tests, the specimen is placed on two fabricated I-beams spanning the chamber and supported on the edges along each side. The main hydraulic testing jack is of 2,000 tons capacity. When not in use it is suspended from a trolley running on rails attached to the upper corners of the chamber. As the load is applied, the weight of the jack is taken off the trolley and the jack bears on the roof. Four 100-ton jacks on similar mountings are also provided. All jacks have universally-jointed heads, and screws for locking them in a fixed position for tests requiring constant deflections. The loads exerted by the jacks are indicated by pressure gauges.

FIG. 4. COMPLETED PRESS.

THE NEWCOMEN SOCIETY.—The summer meeting of the Newcomen Society will be held this year in Norfolk, the headquarters being at King's Lynn, where the members will meet on the evening of Wednesday, June 2. On June 3, visits will be paid to Fring, to see lavender works and stills; Heacham, to inspect a water mill; and Burnham Overy, where there is a wind and water mill, built in 1795. In the evening, the annual dinner will be held, followed by short papers on "The East Anglian Railway Company, 1846-62," by Mr. H. F. Hilton, M.A.; "West Norfolk Engineering," by Mr. R. H. Clark, A.M.I.Mech.E.; and "Norfolk Wind and Water Mills," by Mr. Rex Wailes, M.I.Mech.E. The programme for June 4 includes visits to the yacht-building yard of Messrs. Savage's, Limited, the King's Lynn docks, and an old engine and dynamo at the timber yard of Messrs. Pattrick and Thompson.

ELECTRIC TRACTION IN BRAZIL.

ELECTRIC traction on the 3,000-volt direct-current system has been in operation for many years on the Paulista railway (Companhia Paulista de Estrada de Ferro) in Brazil between its terminus and Jundiai, where it joins the São Paulo railway (Estrade de Ferro Santos a Jundiai). A contract for the electrification of part of the latter railway was let to the English Electric Company, Limited, Queen's House, Kingsway, London, W.C.2, in September, 1946, and good progress has been made since with the work. The new scheme covers the section between Jundiai and Moocha, a distance of 42 miles, where there is a junction some three miles from the important industrial town of São Paulo. The total length of track to be equipped is about 120 miles. Ultimately, it is expected that electrification will be extended to Alto da Sierra and then on to Santos. The line from Jundiai to Santos carries most of Brazil's export traffic in coffee, cotton and other primary products.

The rolling stock for this electrification, which is being supplied by the English Electric Company, is to consist of 15 3,000-h.p. locomotives designed for operation on direct-current at 3,000 volts. These are the largest single-unit electric locomotives which have been made in Great Britain so far and will have a speed of 62·5 m.p.h. The contract also includes three three-coach multiple-unit trains, three mercury-arc rectifier substations with supervisory control equipment and the switchgear and transformers through which power is to be supplied at 33 kV. The overhead track equipment is being manufactured and erected by British Insulated Callenders Cables, Limited, Norfolk-street, London, W.C.2. It consists of steel structural work which, in addition to the contact and catenary wires, will carry duplicate 33-kV circuits for supplying the substations on route, signal circuits and a catenary-suspended supervisory control cable for the remote control of the substations and the track sectioning cabins. The work will involve the erection of about 4,000 tons of steel and 1,000 tons of copper wire for the overhead equipment. Three-quarters of these structures will be of the broad-flange beam type, and are being rolled and fabricated at the works of the Cargo Fleet Iron Company, Middlesbrough. The remainder will be of the lattice-girder type, and are being supplied by Messrs. Painter Brothers, Limited, Hereford. All the copper conductors will be made at the Prescot works of British Insulated Callender's Cables, Limited, and most of the overhead line fittings will be obtained from the same source. Work on the site was begun in March and about 40 per cent. of the concrete foundations for the steel supports have already been completed.

NATIONAL FOUNDRY COLLEGE.—Eighteen students from the United Kingdom and overseas countries are now attending the first post-war session of the National Foundry College, which is housed in the Wolverhampton and Staffordshire Joint Technical College, Wulfruna-street, Wolverhampton. The next session will open on September 27 and will continue until the end of July, 1949. Persons interested can obtain a form of application for admission, together with the prospectus and curriculum, from the Head of the College, Mr. J. Bamford, B.Sc., at the address given above.

INSTITUTE OF BRITISH FOUNDRYMEN.

THE 45th annual conference of the Institute of British Foundrymen will be held in London from Tuesday, June 8, until Friday, June 11. The business meetings, technical sessions and social functions throughout the conference will be held at the Café Royal, Regent-street, London, W.1.

Council and committee meetings will take place during the afternoon of June 8 and the annual general meeting opens at 9.30 a.m. on Wednesday, June 9. After the presentation of awards the presidential address will be delivered by Mr. R. B. Templeton, M.I.Mech.E., the new President. Following this, at 11.45 a.m., Dr. H. Schwartz, of Cleveland, Ohio, U.S.A., will deliver the Edward Williams Lecture on "Some Solved and Unsolved Problems in the Metallurgy of Blackheart Malleable." At 2.30 p.m., two simultaneous sessions will be held, at each of which four papers will be read and discussed. The four at session A comprise: "Nodular Cast Irons, Their Production and Prospects," by Mr. H. Morrogh and Mr. J. W. Grant; "A Quantitative Study of the Residual Gases in Cast Iron," by Dr. R. V. Riley; "Plastic Flow in Cast Iron at Room and Elevated Temperatures, with Special Reference to the Relief of Stress," by Mr. C. R. Tottle; and "The Maurer Diagram and its Modifications," by Dr. H. Laplanche. The four papers at session B comprise: "Steel Castings for Aircraft," by Mr. E. J. Brown and Mr. F. Rodgers; "Steel Casting Cleaning Methods," by Mr. A. B. Lloyd; "Gas Porosity in Nickel-Silver Castings," by Mr. T. F. Pearson, Mr. W. A. Baker and Mr. F. C. Child; and "Aluminium-Alloy Casting Developments," by Dr. E. G. West. The sessions are due to end at 5.15 p.m., and the annual dinner will be held at 7.30 that evening.

On Thursday, June 10, two simultaneous sessions will again be held, both commencing at 9.15 a.m. and timed to end at 12.15 p.m. At each session several papers will be presented, those at session C comprising: "Refractory Materials in the Foundry Industry," by Mr. A. T. Green and Dr. G. R. Rigby; "Problems of Contraction and Distortion in Cast-Iron Castings," by Mr. E. Longden; "New Ladle Methods of De-Sulphurising Pig Iron," by Dr. W. C. Newell; and "Bath Making," by Mr. A. Young. The five papers to be dealt with at session D comprise: "Some Fundamental Problems in Foundry Planning," by Mr. J. Drachmann; "Do You Use Your Cost System?" by Mr. R. L. Lee; "Metallizing in Relation to Foundry Practice," by Mr. J. Barrington Stiles; "Application of the Brinell Test in the Foundry," by Mr. J. Leonard; and "Manufacture of Gravity and Pressure Die Blocks in Nickel-Chromium Iron," by Mr. H. J. Woodman. The afternoon will be devoted to visits to Messrs. J. Stone and Company, Limited, Charlton; the National Physical Laboratory, Teddington; Messrs. R. and A. Main, Limited, Edmonton; Ealing Park Foundry, South Ealing; and the Glacier Metal Company, Limited, Wembley.

The whole of Friday, June 11, will be given to visits to the works of Crane Limited, and Ransomes, Sims and Jefferies, Limited, Ipswich; J. and E. Hall, Limited, and Fraser and Chalmers Engineering Works; Langley Alloys, Limited, and High Duty Alloys, Limited; and Ealing Park Foundry and British Bath Company, Limited.

The offices of the Institute are at St. John-street Chambers, Deansgate, Manchester, 3.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—The ballot for the election of members of the North-East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne, 1, to fill vacancies on the Council, has now been declared. Mr. Mungo Campbell has been elected President and Lt.-Col. R. A. Bartram, Dr. T. W. F. Brown, Mr. J. Bulman, Mr. P. L. Jones, M.C., Mr. J. B. Kerr, Mr. W. Muckle, and Dr. A. Pickworth, have been elected ordinary members of the Council. Mr. J. W. Elliot is to be an associate on the Council and Mr. W. H. Pilmour has been re-elected honorary treasurer.

EFFECTS OF MICRO-ORGANISMS ON ADHESIVES.—In a bulletin recently published by Messrs. Aero Research Limited, Duxford, Cambridge, it is stated that animal and starch glues, blood albumin and casein were at one time the only adhesives available for wood and other materials, and that they are liable to break down completely under damp conditions as a result of decomposition by moulds and bacteria. The bulletin adds that synthetic-resin adhesives have had a profound effect on the character of glued joints of all kinds. Phenolic-resin glues of the film or liquid type, whether hot- or cold-setting, and all types of urea-resin glues, either neat or containing not more than 33 per cent. of flour, are unaffected by the attack of micro-organisms. On the other hand, urea resins extended with more than 50 per cent. of flour can be destroyed by micro-organisms.

BRITISH STANDARD SPECIFICATIONS.

THE following publications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.

Glossary of Weld Imperfections.—An addition to B.S. No. 499-1939 which is a glossary of terms relating to the welding and cutting of metals, has recently been issued. This publication is designated B.S. No. 499: Part 2: 1948, and deals with the definitions of terms for surface imperfections and internal defects in a weld or in the adjacent metal, which defects can be identified by radiographic means. There is a standard definition for each term, together with a description of the radiographic appearance. Where alternative terms are known they are grouped together, those given first being recommended for use, and the others being deprecated. The publication covers 29 main terms, some of which include subsidiary terms. There are 27 illustrations; 17 of them are half-tone reproductions of radiographs or macrophotographs. [Price 2*s.* 6*d.*, postage included.]

Annealed Steel Wire.—A new specification, B.S. No. 1429-1948, covers annealed steel wire for oil hardened and tempered springs for general engineering purposes. A range of qualities of plain carbon steels and two types of alloy steels are included. The latter are silicon-manganese and chromium-vanadium steels, as specified in B.S. No. 970 covering wrought steels. For each type of wire two grades are provided, namely, grade 1: ground and grade 2: unground. In view of its complete freedom from decarburisation and surface defects, ground wire is recommended for applications in which it is essential to have the highest possible resistance to fatigue failure. The section on general clauses includes details of manufacture, information on tests on the rod from which a wire is produced, methods of test on the wire and dimensional tolerances. For each steel, chemical-composition and acceptance tests are specified. [Price 2*s.*, postage included.]

BOOKS RECEIVED.

Shots at the Truth. By SIR ALFRED HERBERT, K.B.E. Alfred Herbert Limited, Coventry. [Price 15*s.* 9*d.*, post free.]

British Engine Boiler and Electrical Insurance Company, Limited. Technical Report for 1938. Offices of the Company, 24, Fennel-street, Manchester, 4. [Limited number of copies available to approved firms, Institutions, etc.]

Ministry of Works. The Distribution of Building Materials and Components. Report of the Committee of Enquiry Appointed by the Minister of Works. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2*s.* 6*d.* net.]

Department of Scientific and Industrial Research. Food Investigation. Special Report No. 53. *The Physics of Drying in Heated Air, with Particular Reference to Fruit and Vegetables.* By A. J. EDE and K. C. HALES. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* net.]

The Model Railway Hobby. By M. H. BINSTEAD. Percival Marshall and Company, Limited, 23, Great Queen-street, Kingsway, London, W.C.2. [Price 10*s.* 6*d.* net.]

Milling in the Lathe. By EDGAR T. WESTBURY. Percival Marshall and Company, Limited, 23, Great Queen-street, Kingsway, London, W.C.2. [Price 3*s.* 6*d.* net.]

Gears, Gear Production and Measurement. An Introduction to Gearing Work, Including Special Reference to Inspection Methods. By A. C. PARKINSON and W. H. DAWNEY. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 25*s.* net.]

Uniform Cost Accounting for Steel Fabricating and Kindred Industries. Prepared by the TANK AND INDUSTRIAL PLANT ASSOCIATION. Gee and Company (Publishers), Limited, 27-28, Basinghall-street, London, E.C 2. [Price 25*s.* net.]

Ministry of Education. Science Museum. Darkness into Daylight. An Account of the Past, Present and Future of Man-Made Illumination. By W. T. O'Dea. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* net.]

The Railways of Britain: Past and Present. By O. S. NOCK. B. T. Batsford, Limited, 15, North Audley-street, Mayfair, London, W.1. [Price 15*s.* net.]

Fitting. Small Tool Making, Lathe Work, Screw Cutting, Shaping and Applied Workshop Technology. By A. E. LEESON and P. SAMPSON. Second edition. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 7*s.* 6*d.* net.]

Industrial Electric Furnaces and Appliances. Volume II. By DR. V. PASCHKIS. Interscience Publishers, Incorporated, 215, Fourth-avenue, New York 3, U.S.A. [Price 8 dols.] Interscience Publishers, Limited, 2a, Southampton-row, London, W.C.1. [Price 48*s.*]

PERSONAL.

SIR ROBERT BURROWS has been appointed a part-time member of the National Coal Board and, at his own request, will receive no remuneration.

MR. E. A. EVANS, M.I.Mech.E., F.R.I.C., has been elected President of the Institute of Petroleum for the session 1948-49. The honorary treasurer is MR. G. H. COXON and the honorary secretary, MR. C. CHILVERS, B.Sc., F.R.I.C.

DR. F. J. WILKINS, M.Sc., who has been Director of Chemical Research and Development, Ministry of Supply, since April, 1946, has been appointed to succeed DR. E. T. PARIS, C.B., F.Inst.P., as Principal Director of Scientific Research (Defence) in the Ministry. Under the Controller of Supplies (Munitions) and the Chief Scientist, Dr. Wilkins will be responsible for research on munitions and allied equipment.

The Divisional appointments made by the British Electricity Authority, Merseyside and North Wales Division, Clarkes-gardens, Woolton, Liverpool, include those of MR. R. L. BATLEY, A.M.I.Mech.E., as chief generation engineer (operation); MR. D. F. GRANT, A.M.I.E.E., and MR. H. BERRY, M.Eng., A.M.I.Mech.E., A.M.I.E.E., as senior assistant engineers (efficiency); MR. W. J. NORRIE as mechanical maintenance engineer; and MR. F. H. S. BROWN, B.Sc., A.M.I.Mech.E., A.M.I.E.E., and MR. A. N. DUFFETT, B.Eng., A.M.I.E.E., as generation engineers (construction).

Among recent appointments to the Southern Electricity Board, Maidenhead, Berkshire, of which MR. H. NIMMO, M.I.C.E., M.I.Mech.E., M.I.E.E., is chairman, are those of MR. H. C. RUDD, as cable engineer, and of MR. L. R. BROCK, as assistant plant and equipment engineer, in the chief engineer's department.

MR. A. HAYWOOD, who has been on the staff of the Marketing Division of the National Coal Board and was formerly Coal Supplies Officer in South Wales, has been appointed contracts manager in charge of revenue purchases, British Electricity Authority, Great Portland-street, London, W.1.

MR. W. S. DOUGLAS, B.Sc., has been elected an additional vice-president of the British Refrigeration Association, 1, Lincoln's Inn Fields, London, W.C.2, for the year 1948.

MR. E. WRAY FOX and MR. R. E. OTTER have been nominated to represent the Institution of Heating and Ventilating Engineers on the Heating and Ventilating Engineering Advisory Committee of the City of Birmingham.

MR. H. H. CUNDELL has been appointed sales manager, of the British Aluminium Company, Limited, Salisbury House, London Wall, E.C.2, while MR. A. W. LANGHAM will continue to be responsible for the sales-planning department, with the title of sales-planning manager as before. MR. E. E. SPILLETT has been appointed development manager in place of Mr. Cundell and MR. P. S. W. SWABEY has been made assistant development manager in place of Mr. Spillett. All these appointments took effect on May 1.

MESSRS. CIBA LIMITED, have acquired a controlling interest in AERO RESEARCH LIMITED, Duxford, Cambridge, the organisation conducting the manufacture of industrial adhesives and research work on synthetic resins. Large-scale expansion of both research facilities and production resources have been approved and the company will continue under the managerial control of the directors, DR. N. A. DE BRUYNE and MR. R. F. G. LEA.

THE ASSOCIATED EQUIPMENT COMPANY, LIMITED, Southall, Middlesex, have opened a London office and overseas sales department at 7, Chesterfield-gardens, Curzon-street, W.1. (Telephone: REGent 4318-9; Telegraphic address: Vangastow Phone London). MR. J. M. E. FELL, the firm's overseas sales manager, and MR. P. J. ARROW and MR. P. RACKHAM, divisional managers for North London and the eastern counties, and South London and the south-eastern counties, respectively, have their offices at the new address.

PRACTICAL EXPERIENCE IN ELECTRICAL ENGINEERING.—A subject of interest to the younger generation was debated at a meeting of the London Students' Section of the Institution of Electrical Engineers on Monday, April 19. Mr. D. A. Denison raised the question whether all practical experience should be gained with one employer or with several. There was much, he said, in favour of staying with one large organisation which manufactured a variety of electrical equipment as, if the student passed through all the departments, he gained all-round experience. Furthermore, after gaining this experience, he could specialise and become thoroughly competent in one section. On the other hand, the man who moved from one firm to another acquired experience in different methods of production and also gained psychologically, in that he was better able to judge his own value in an entirely new environment. Lack of housing was mentioned as one of the obstacles to changing jobs at present.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel.—There is no diminution in the demand for steel, but it is reported that some foreign buyers, especially the Danish, are tending to become more selective. This is probably explained by their shipbuilding needs, but the movement is being watched in case it turns out to be the first sign of a decline in the export demand. Production is reported to be about normal this week, with melting furnaces again in full production. This indicates an improvement in the scrap position, but full capacity production here must have large imports of scrap, even if the maximum home collection is maintained. Pig iron production is satisfactory. Ore is plentiful and coke has been in adequate supply. Billets and slabs have also been plentiful, except that there is sometimes a scarcity of billets under 3 in. square. In the sheet trade the heavy demand for light-gauge sheets shows no sign of weakening, and exports of black and galvanised sheets are limited only by the quotas. Some sheets will be shipped to Eastern and Western Canada this period, but again the quantities will be small owing to quota limitations. Slabs for medium and heavy plates are in good supply but sheet bar is scarce.

Scottish Coal.—Low outputs have been prevalent during the week. It was stated recently that Scottish miners are now bringing up 3 cwt. more than they did at this time last year. What was not said was that this figure was based on a period of snowy weather when outputs were necessarily low. Actually, it is estimated that the increase is more like 1½ cwt., despite the increasing use of machinery. The output for the week ended May 1 is likely to be well below the 497,000 tons for the previous week. That figure was somewhat inflated by the fact that the men, or some of them, worked on the Saturday so that they could have May Day as a holiday. In point of fact, absenteeism was high that day. Output for the current week will be cut by the May Holiday and by the fact that about 4,500 tons were lost through unofficial strikes at Comrie and Auchincruive. Overall Lanarkshire production is expected to be nearly 1,000 tons lower. The week ending May 8 is likely to be even worse, as Monday and Tuesday are statutory holidays.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Welsh Coal Trade.—With outputs steadily maintained and home demand beginning to show its seasonal slackening, exports of coal from South Wales during May are expected to reach their highest level since the early days of the war. The expansion that has already taken place in exports this year was reflected in the official returns of the trade passing through the six principal South Wales ports. These showed that, in the period January 1 to April 18, the amount of coal and coke handled was 1,657,724 tons, against 1,429,523 tons a year ago. Exports of patent fuel were nearly doubled, at 90,804 tons. It was reported that France was to receive about four times as much coal as of late. Deliveries to this market in recent months have been on the basis of about 24,000 tons of British coal a month, of which about half has been taken from South Wales. Under the new arrangement the proportion should remain unchanged. Portugal was also expected to receive more coal, as also was West Italy, while Canada was getting about 20,000 tons of anthracites a month. Deliveries to Argentina have been slowed up by the shortage of suitable ships, owing to their diversion to the Australian grain trade. The inland trade is brisk. Demand is steadily maintained from the principal home users and already there are sufficient orders in hand from these to account for the bulk of productions of the better sorts for some time. Cokes and patent fuel are in steady demand and not easy to secure for early delivery.

Swansea Steel-Sheet Industry.—The market report issued by the Incorporated Swansea Exchange states that, last week, the demand for tin-plates was in excess of the current production. Nevertheless, a satisfactory volume of business was transacted. Makers are maintaining steady outputs and could do much more if the requisite labour and steel were available. The export market has been rather more active and increased orders have been booked. Steel sheets and iron and steel scrap continue to be in great demand.

DRILLING JIG.—A jig for drilling holes diametrically through round bars has been introduced by Messrs. S. H. Bridson, Limited, 480, Portway, Bristol, for whom Messrs. Brooks and Walker, Limited, 41, Dockhead, London, S.E.1, are the agents. It consists principally of two V-blocks, in line with each other and held by a tie bar slotted for adjusting the distance between them; an angular component fixed to one V-block, forming a housing for the drilling guide bush and also acting as a screwed clamp for the rod; and an adjustable stop for fixing the position of the hole to be drilled in relation to the end of the rod.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Complaints are still heard of shortages of some qualities of steel, the lack of which makes it necessary to work short time in some departments. Makers of edge tools cannot get enough steel for fork manufacture, and the agricultural-steel trades generally have not enough high-carbon steel sheets and bars to enable them to complete numerous orders for machine parts. Iron and steel foundry reorganisation and re-equipment is going ahead. Makers of colliery wheels, in consequence, have been able to step up production considerably. Other reorganisation is delayed by delays in the delivery of machine tools. A Sheffield firm, Messrs. Howell and Company, Wincobank, have secured an order for 62,000 steel boiler tubes for an Argentine railway company. The tubes are of different sizes and will weigh about 1,000 tons; the value of the order is about 75,000*l.* Rising costs of production are a continual source of anxiety: some thousands of steelworkers have been granted an advance of 7*s.* 2*d.* for a six-shift week. It is retrospective, in part, from the middle of February.

South Yorkshire Coal Trade.—Production from deep mines is about normal again, and in some cases collieries have exceeded targets. This enables some arrears of delivery which accumulated during the period of the shotfirers' dispute, to be cleared. More coal is being allocated for export. The demand for coking coal is increasing and allocations are being improved to permit coke works to build up stocks of hard coke, the demand for which for the iron and steel trades is very heavy. The output of open-cast coal is improving, and a larger proportion is being directed to the industrial and domestic sections.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The total production of iron and steel remains at a high level and is being distributed more satisfactorily than of late. No doubt there has been maladministration of priority deliveries of material but, with the stricter control now imposed, customers' needs are receiving attention that leaves less ground for complaint than has been the case for some time. Further increase in the production of the Cleveland ironstone mines is expected and imports of foreign ores are being maintained on a scale sufficient to cover users' requirements. The scarcity of iron and steel scrap remains acute, but rather larger parcels are coming forward from home sources and imports from Germany are expected to improve in the near future. Stocks of pig iron are very low.

Foundry and Basic Iron.—To cope with their delivery obligations, foundry owners are in urgent need of larger quantities of pig iron and scrap. Almost the whole of the foundry pig going into use in the North East Coast area has to be delivered by rail from the Midlands and supplies from that producing centre are, at times, irregular and are not always adequate for consumers' requirements. The output of the basic blast-furnaces is barely sufficient to keep the local consuming plants in operation at the present level, but some further increase in the make is anticipated.

Hematite, Low-Phosphorus and Refined Iron.—The tonnage distribution of East Coast hematite is sufficient for the essential needs of customers of long standing, but larger deliveries would be welcome. The make of low-phosphorus grades of iron is steadily absorbed and manufacturers of refined qualities have ready outlets for their products.

Manufactured Iron and Steel.—Firms supplying the demand for semi-finished and finished iron have as much work in hand as they can deal with and bookings for the various descriptions of steel are heavy. Substantial parcels of steel semies are now obtainable from home makers, but imported commodities are still very scarce. Re-rollers could deal with larger quantities of billets and sheet bars than they are receiving. The heavy rolling mills are operating at the capacity limit; the new system of delivery allocation of distributable tonnage is reported to be working smoothly.

PORTABLE MARKER LIGHTS FOR AVIATION.—Fittings which have been designed for use as portable flashing marker lights at airports or to indicate obstructions on highways have been placed on the market by the Westinghouse Electric Corporation, 306, Fourth-avenue, Pittsburgh 30, Pennsylvania, U.S.A. One of these fittings is intended for use at night only, while the other, in which the light source is mounted on a lead-coated steel cone finished in international orange, is effective both at night or during the day. The light source for obstruction marking is a coiled neon tube, which is supplied from a dry battery with an average life of 150 hours when flashed 120 times a minute. For other applications, white, gold, green or blue fluorescent lamps can be used.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, May 11, 5.30 p.m., Great George-street, S.W.1. (i) "Coast Erosion and Sea Defence, with Special Reference to Problems on the East Coast of England Associated with the Former London and North Eastern Railway," by Mr. T. H. Seaton. (ii) "The Effect of Winds and Tides on Sea Coast Defence Works in North Wales," by Mr. C. R. Irving. *Newcastle-upon-Tyne Association:* Tuesday, May 11, 6.15 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. Annual Meeting. *Birmingham Association:* Thursday, May 13, 6 p.m., James Watt Memorial Institute, Birmingham. Annual Meeting. Discussion on "The Engineer's Part in Public Affairs," opened by Mr. H. J. B. Manzoni.

INSTITUTION OF ELECTRICAL ENGINEERS.—*Radio Section:* Tuesday, May 11, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. (i) "Carrier Frequency Shift Telegraphy," by Messrs. R. Ruddlesden, E. Forster and Z. Jelonek. (ii) "Some Developments in Communication Point-to-Point Radiotelegraphy," by Mr. J. Smale. (Postponed from May 5). *Transmission Section:* Wednesday, May 12, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. "Transformer Economic Efficiency," by Mr. B. Calvert. *South Midland Students' Section:* Wednesday, May 12, 6.45 p.m., James Watt Memorial Institute, Birmingham. "Thermostatic Controls," by Mr. R. S. Atkins. *Institution:* Thursday, May 13, Savoy-place, Victoria-embankment, W.C.2, 5.30 p.m., Annual Meeting, for corporate members and associates only. 6.45 p.m., Film on "Atomic Physics."

INSTITUTE OF MARINE ENGINEERS.—Tuesday, May 11, 5.30 p.m., 85, The Minories, E.C.3. "Some Aspects of the Manufacture of Large Seamless Steel Tubes and Hollow Forgings," by Mr. J. W. R. Naden.

INSTITUTION OF PRODUCTION ENGINEERS.—*Wolverhampton Graduate Section:* Tuesday, May 11, 7.15 p.m. Technical College, Wolverhampton. "Fine Measurement," by Mr. L. Wilcox. *Wolverhampton Section:* Wednesday, May 12, 7 p.m., Wisemore Schools, Walsall. "Metallurgical Factors Influencing Machinability," by Mr. L. W. Johnson.

INCORPORATED PLANT ENGINEERS.—*Manchester Branch:* Tuesday, May 11, 7.15 p.m., Engineers' Club, Albert-square, Manchester. Informal Discussion. *Newcastle-upon-Tyne Branch:* Thursday, May 13, 7.30 p.m., Y.M.C.A., Connaught Rooms, Newcastle-upon-Tyne. "Steam Economy," by Mr. E. Hurle.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*South-West London Branch:* Tuesday, May 11, 8.15 p.m., Compton Hall, Wimbledon, S.W.19. "Installation and Testing," by Mr. J. P. Mulville.

INSTITUTE OF PETROLEUM.—Wednesday, May 12, 5.30 p.m., Manson House, 26, Portland-place, W.1. Films showing various phases of the petroleum industry.

JUNIOR INSTITUTION OF ENGINEERS.—Friday, May 14, 6.30 p.m., Royal Society of Arts, John Adam-street, W.C.2. "Coal, Oil, Chemicals," by Dr. J. G. King.

INSTITUTE OF METALS.—Thursday, May 13, 6 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. May Lecture. "Search for Metals by Physical Methods," by Professor A. O. Rankine.

NATIONAL PHYSICAL LABORATORY.—An "open day," to which representatives of industrial organisations are being invited, is to be held at the National Physical Laboratory from 2.30 to 6 p.m., on Monday, June 21. The wide range of scientific research and other work undertaken at the Laboratory is already well known to industry, but there may still be a large number of firms with which the Laboratory has no contact. Some of these will, no doubt, wish to take this opportunity of seeing the scope of the Laboratory's activities and a number of invitations is being reserved for this purpose. Accredited representatives of industrial organisations are invited to communicate with the Director, at Teddington, Middlesex, not later than June 5.

FILM ON MEASURING AND INSPECTING.—A sound-film entitled "Precise Measurement for Engineers" has been made by the Central Office of Information for the Department of Scientific and Industrial Research. It runs for about 30 minutes, and, in addition to explaining the functions of gauging and quality control, it shows the value to industry of the work of the Metrology Division of the National Physical Laboratory. The film, which is suitable for 16-mm. projectors, will be available shortly for free loan to technical colleges, firms, and other bodies, from the Central Film Library, Imperial Institute, London, S.W.7. If it is also desired to borrow a projector, application for it, and for the film, should be made in the first instance to the Films Division, Central Office of Information, Norgeby House, Baker-street, W.1.

EXHIBITS AT THE BRITISH INDUSTRIES FAIR, BIRMINGHAM.

(*For Description, see Page* 437.)

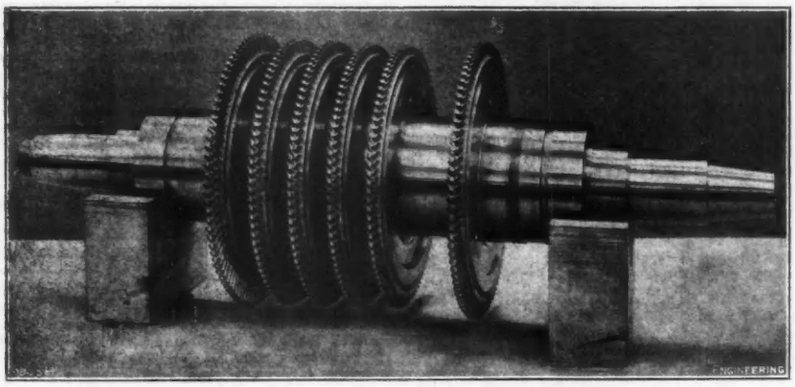


FIG. 8. AXIAL-FLOW TURBINE ROTOR; BRUSH ELECTRICAL ENGINEERING COMPANY, LIMITED.

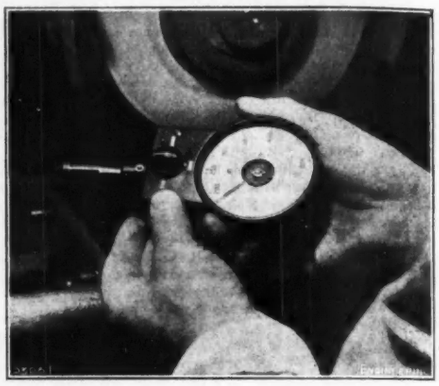


FIG. 9. HAND TACHOMETER; MESSRS. A.T. INSTRUMENTS, LIMITED.

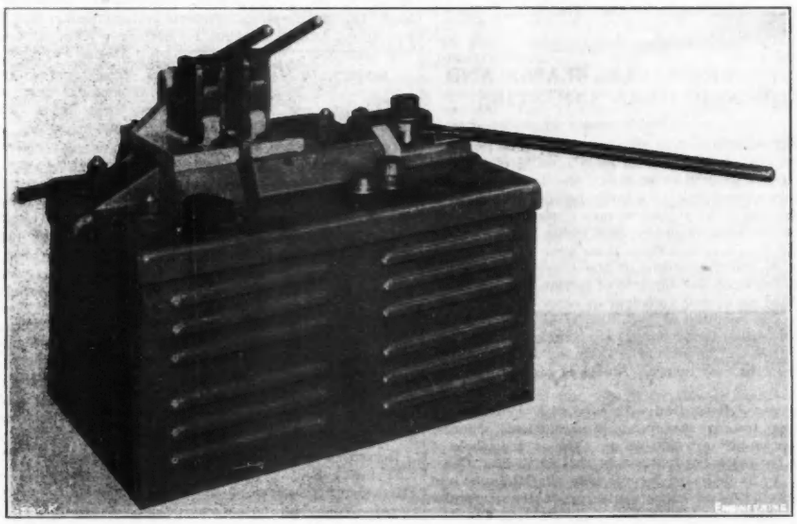


FIG. 10. 30-kVA FLASH WELDER; BRITISH INSULATED CALLENDER'S CABLES, LIMITED.

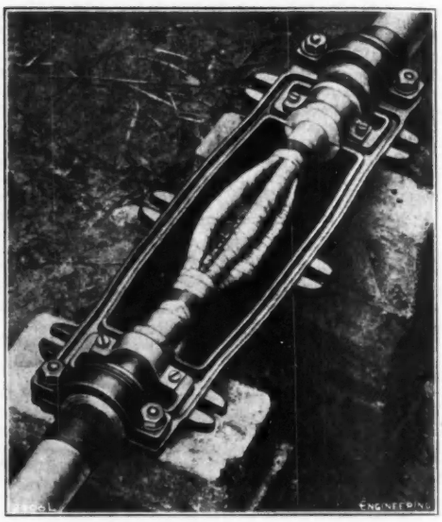


FIG. 11. STRAIGHT-THROUGH COMPOUND-FILLED JOINT; MESSRS. JOHNSON AND PHILLIPS, LIMITED.

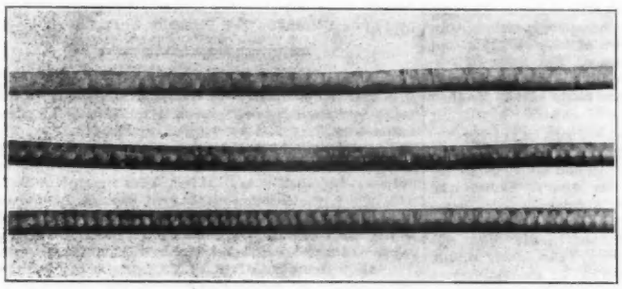


FIG. 12. CABLES AFTER SUBJECTION TO BENDING TESTS; MESSRS. JOHNSON AND PHILLIPS, LIMITED.

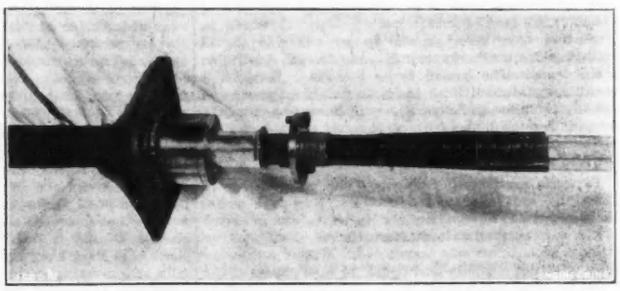


FIG. 13. MECHANICAL UNION FOR ALUMINIUM-SHEATHED CABLES; MESSRS. JOHNSON AND PHILLIPS, LIMITED.

INSTITUTION OF MINING ENGINEERS.—The 105th general meeting of the Institution of Mining Engineers will be held in Newcastle-upon-Tyne, from Wednesday, June 9, to Friday, June 11. The meeting opens at 2.15 p.m., on June 9, in Neville Hall, Newcastle-upon-Tyne, 1, when, after a civic welcome by the Lord Mayor of Newcastle, two papers will be presented for discussion, namely, "Second Report of the Shot-Firing and its Alternatives Committee," and "The Composition of Nitrous Fumes from Shot-Firing," by Mr. J. Ivon Graham and Mr. F. Lawrence. In the evening, at 7 o'clock, a reception and dance will be held by the Lord Mayor and Lady Mayoress at the Grand Assembly Rooms, Barras Bridge. Alternative visits to Lynemouth Colliery, near Ashington; Silksworth Colliery, near Sunderland; Norwood Coke Works, Dunston-on-Tyne; and to Borcovicus to view the Roman remains, have been arranged for June 10, and in the evening, at 7 for 7.30, the Institution dinner will be held at the Royal Station Hotel. The last day of the meeting, Friday, June 11, will be devoted to visits to the Hebburn and Newtown Works of Messrs. A. Reyrolle and Company, Limited, and to the works of Messrs. Hugh Wood and Company, Limited, in the Team Valley Trading Estate. The offices of the Institution are at 436, Salisbury House, Finsbury Circus, London, E.C.2.

COIL SPRING FEDERATION RESEARCH ORGANISATION.—The annual meetings of the Coil Spring Federation and the Coil Spring Federation Research Organisation, 301, Glossop-road, Sheffield, 10, are to be held at the Queen's Hotel, Birmingham, on Wednesday, May 12. After the meetings, at 2.30 p.m., a lecture entitled "Prestressing of Springs with Special Reference to the Internal Stresses Induced," will be delivered by Dr. J. A. Pope, Wh.Sc., and will be followed by a discussion.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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ADVERTISEMENT RATES.

Terms for displayed advertisements on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for inserts, can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 8*s.* for the first four lines or under, and 2*s.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 24*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Wednesday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received at least 10 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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ENGINEERING

FRIDAY, MAY 7, 1948.

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THE DEVELOPMENT OF INVENTIONS BILL.

THE article entitled "The Nationalisation of Invention," which appeared on page 421 of last week's issue of ENGINEERING, necessarily had to be written in advance of the second-reading debate in the House of Lords on the Development of Inventions Bill, and, of course, with no knowledge of the direction which that debate might take. The matter appears to be of such importance, however—not only because of the course of action clearly envisaged in the Bill, but also because of the latitude permitted by its more general clauses for the prosecution of policies which are not so precisely defined—that a summary of the more significant contributions seems desirable by way of an appendix to the former article. The debate took place on Thursday, April 29, and, on its conclusion, the motion for the second reading was carried and the Bill referred to a Committee of the whole House.

The motion for the second reading was introduced by the First Lord of the Admiralty, Viscount Hall, who said that its purpose was to ensure that full and proper use was made of British inventions, to secure for the country the benefit of inventions resulting from public research, "and of any other inventions which are either not taken beyond the laboratory stage or are insufficiently developed or exploited." He stressed more particularly the fact that it was not the business of the research stations of defence departments to find civilian uses for their inventions. Similarly, the research stations controlled by the Department of Scientific and Industrial Research could not be expected to turn aside from their proper function of conducting fundamental research in order to carry their discoveries through the development stages or to undertake their commercial exploitation. (No one took the opportunity to inquire in the debate why, if this were so, the word "Industrial" had formed part of the title of the D.S.I.R. since its inception.) Lord Hall then adduced the cases of Babbage, with his calculating machine, and Perkin, the discoverer of aniline dyes, as arguments in favour of Government action to aid in the development and exploitation of inventions; and disclosed that the proposal for an independent organisation to take over the inventions arising from Government research had originated with the Scientific Advisory Council. He added that the proposals in the Bill did not affect the present law of patents, and explained—which was not explicit in the Bill—that the proposed corporation would have "no powers beyond those inherent in any other legal person or association"—in fact, "in so far as they obtain their inventions from private persons, the Corporation have to do this by freely-negotiated contract."

In conclusion, Lord Hall stated that the Corporation would not engage in general manufacture or trading; normally, they would exploit inventions through established industry. In the exceptional case where industry declined to take up an invention which they believed to be good and valuable, the Corporation might arrange on their own account for manufacture and distribution; but they would have to obtain the consent of the Board of Trade before so doing, and they would only concern themselves in this way with their own inventions. The principles of the Bill, he added, were supported by the Chartered Institute of Patent Agents, the Trades Union Congress, and the Medical Research Council; and the Federation of British Industries, which had been consulted, had "expressed certain views which would receive full consideration."

Lord Swinton, who was the next speaker, took exception to the inclusion of the aniline dye industry as an argument in favour of the Bill, maintaining that the reason why this was developed mainly abroad was that the absence, at that time, of any protective tariff allowed the British dye industry to be killed by foreign competition. He quoted the results of an investigation by Mr. Kenneth Swan's Committee on Patent Law into the persistent allegations that industry habitually acquired patents in order to suppress inventions, as evidence that there was no solid foundation for such rumours; the Swan Committee, he said, had "formed the opinion that this type of restriction has been much exaggerated" and that the rumours were "generally due to the unfulfilled expectations of over-sanguine inventors." On the wording of the Bill, however, he criticised the vagueness attaching to the phrase "in the public interest," holding that the interpretation of "public interest" would probably depend on the views of the Corporation. If no private invention was to be taken over unless by freely negotiated agreement, he found it hard to understand why Clause 1 went into so much detail about the Corporation's powers; it should be sufficient to say that the Corporation should have power to enter into an agreement with the owner of a patent or process or invention in order to acquire and develop it. He wished for a more definite assurance that there was to be "no compulsory acquisition of any sort or kind."

It would appear also, Lord Swinton continued, that, under Clause 1 (3), the Corporation could not only acquire a patent right, but could set up a factory to exploit it, using the taxpayers' money for the purpose. It would be wise, he thought, to make it more clear that, where an invention was to be exploited commercially, the Corporation would seek to do this on proper terms through the medium of existing industry; though he admitted that, if this could not be accomplished, and they were convinced that something of the sort should be done, then they should have power to do it themselves. Another point that was in doubt was the precise significance of the term "financial assistance . . . provided out of public funds"; did this mean that, if the assistance was only, say, a modest grant of 5 per cent. or so the Corporation would have some special power of acquisition or control?

The general tone of the next contribution to the debate, that of Lord Strabolgi, rather suggested that there was some substance in the doubts expressed by Lord Swinton. Lord Strabolgi stressed strongly the argument that various notable inventions had been retarded by the use of "blocking patents";

instances which he alleged were the opposition of the button-making industry to the zip fastener, of the match industry to the so-called "everlasting match," and the report by the Federal Communications Commission, in the United States, that "the Bell Telephone Company had suppressed no fewer than 3,400 patents, simply to forestall competition." It may be remarked, in this connection, that Lord Swinton's quotations from the findings of the Swan Committee, while they were, no doubt, accurate, were not entirely conclusive; the fact that evidence of obstructive or repressive tactics was difficult to obtain and scanty in amount is hardly to be taken as a quantitative measure of their extent. There have been cases in the engineering industry of mergers between erstwhile competitors, followed by the disappearance from the market of the products of one of the firms concerned; not quite the same process as was described by Lord Strabolgi, but one of similar effect.

Lord Maugham, "speaking as a lawyer," professed to find nothing in the Bill which would give the Corporation any power of compulsory purchase, but he objected, as Lord Swinton had done, to the looseness of its wording. "It is a bad principle," he said, "to have excellent intentions in a Bill and not to limit, define or explain what those intentions are"; it appeared to him that, apart from exercising compulsory powers, the Corporation would be able to do practically anything—with the consent of the Board of Trade, they could go into industry and carry on almost any industry in the world. As Lord Strabolgi had done, he seemsd to find in the Bill (of which he claimed to be "a wholehearted supporter") an invitation to the small and impecunious inventor to cast his financial burdens upon the Corporation; an interpretation for which there appears to be no positive warrant in the text of the proposed measure. That Lord Maugham appreciated this point was evident from his request that the remarks of Viscount Hall on sub-section (1) of Clause 1 might be further elucidated, as it seemed that "the real object of the Bill is to be found in the speech of the noble Viscount rather than in the Bill itself." The great value of the Bill, he considered, was that people who were without any protection could apply for assistance from the Corporation—otherwise, they might be totally unable to have their patents exploited.

The Government reply to the debate, by Lord Chorley, did not entirely answer the queries raised, but this was only to be expected; the most that a spokesman could do in such circumstances would be to promise that the grounds for criticism would be investigated. An extempore effort to clarify the complexities of legal draftsmanship would probably result merely in a worse complexity, and possibly some embarrassment to the sponsors of a Bill. Lord Chorley did, however, express the opinion that the purchase of patents for the purpose of suppressing them was not widespread in this country; and he revealed the interesting detail that there had been only four applications, under Section 27 of the existing Patents Act, for a compulsory licence to work a patent which had not been effectively used. The proposed Corporation, he continued, would have the same rights as anyone else to make application under Section 27, but "they will have no other rights than those of any other person." Then came a rather curious example of Parliamentary "hedging"; referring to the desire of Lord Swinton to be "quite certain that the Bill confers no powers of compulsory acquisition upon the Corporation," a point on which he had given previous notice so that an answer might be forthcoming. "I have taken advice," said Lord Chorley, "and I am satisfied that that is so"; but then he added, "Of course, I admit that what I say carries very little weight, compared with the opinion of one of the greatest authorities in the land, Lord Maugham"—a very astute observation, which might be interpreted to mean almost anything. On the question of the meaning of "public interest," Lord Chorley was hardly more explicit. What he did say definitely, in conclusion, was that "It is one of the main objects of this Bill that inventors shall in future have a real run for their money." It seems quite possible that some of them may have it.

WATER POLLUTION RESEARCH.

THE problems involved in the study of water pollution cover the treatment of unsatisfactory supplies in order to render them suitable for domestic and industrial use; the processing of sewage and trade wastes in order to bring them into such a condition that they may be discharged into rivers or streams without deleterious effect; and investigations of methods of preventing the pollution of either surface or underground sources of supply. Initial study of any of these matters lies mainly in the fields of chemistry and biology, but large-scale application of any remedial process which may be devised introduces problems of an engineering nature. In the report of the Water Pollution Research Board covering the war period, which was published last year, it was stated that the formation of an engineering section of the laboratory had been suggested. In the latest report,* Mr. H. W. Cremer, the Chairman, states that "it has been decided to form a nucleus of an engineering section which can be enlarged when further accommodation is available." The present laboratory at Watford is hardly adequate for the work being carried on and, quite apart from the addition of an engineering section, it has been decided in principle that entirely new premises shall be built.

The formation of "a nucleus of an engineering section" presumably means that one or more engineers are to be added to the staff. At present they can have no adequate workshop or laboratory facilities but may clearly be of assistance in the design of plant for the large-scale application of processes worked out. The activities of the laboratory staff are concerned to a considerable extent with the application of methods devised to actual installations, and although in many, or in most, cases actual design may remain in the hands of the firm undertaking the installation, it will be an advantage for the laboratory staff to be specifically represented on the engineering side. An example of large-scale work which has been carried on under the auspices of the laboratory for many years is furnished by a system of alternating double filtration of sewage which is in operation at the Minworth works of the Birmingham, Tame and Rea District Drainage Board. No doubt the purely engineering aspects of this work have been supervised by the staff of the Drainage Board, and it is not likely that they will be eliminated when the engineering section is formed.

The greater part of the annual report, which is contributed by Dr. B. A. Southgate, the Director of the laboratory, is necessarily of a chemical and biological nature, and to a considerable extent lies outside the sphere of this journal, although some of the matters dealt with are of direct interest to sanitary engineers. One section of the report, however, concerning the treatment of waste waters containing oil, deals with a matter of importance to large numbers of works managers. The large-scale installation was designed in collaboration with a firm of consulting engineers and, no doubt, a similar procedure may be followed in connection with other commercial installations, but the case forms an example of the many in which it would be an advantage to all parties for the laboratory staff to include specifically engineering members. It is not necessary to refer here to any details of this installation as it was fully described in an article appearing in our issues of June 20 and June 27, 1947.

The work of the laboratory staff is by no means confined to operations which can be carried on at Watford. Researches are conducted in many parts of Great Britain and abroad. An example of the latter is furnished by the investigations being carried on in Kenya by a member of the staff working in conjunction with the East African Industrial Research Board. The work is concerned with the pollution of relatively small streams in East Africa by waste waters from the processing of coffee and sisal. A semi-scale treatment plant has been erected near Nairobi, and it is hoped to develop methods whereby the waste liquids can be treated sufficiently to enable them to be re-used in the processes of manufacture. The co-operation with another official body in this work is but one example of the varied contacts which are maintained. For instance, investigations concerned with the choosing of factory sites from the point of view of possible pollution of streams and surface waters by the proposed industrial activities have been carried on in conjunction with the Department of Agriculture of Northern Ireland and the Department of Health for Scotland.

An important investigation some details of which are given in the report is concerned with the pollution of the River Avon. Initially it was proposed to carry out experiments to determine the effects of chlorinating the sewage effluent from the City of Coventry on the sanitary quality of the river, but the project was abandoned when it was found that chlorinated effluents were highly toxic to fish. The effect is due to the formation of cyanogen chloride produced by the reaction of chlorine with thiocyanate, which is a constituent of gas liquor added to the sewage. The bacteriological survey of the river showed that the effect of sewage effluents was to cause a large immediate increase in the number of bacteria in the water, but that the numbers rapidly decreased below the point of discharge, suggesting that the bacteriological quality of the river water would be affected to a greater extent by small discharges of polluting matter immediately above the point of sampling than by much greater discharges from Coventry some miles upstream.

One of the researches of which some details are given may be regarded as of some general public interest; it was concerned with the control of the nuisance from filter flies. At Minworth, large numbers of *Anisopus* emerge from the filters in the spring months, but at other works in the Birmingham area the flies emerging from April to October were mainly *Psychoda*. The problem presented is to control the emergence of flies without at the same time killing other organisms which feed on the filter film and assist in keeping a filter free from excessive accumulation of organic matter. The experimental work carried out consisted in the treatment of percolating filters with insecticides, D.D.T. and Gammexane being used, and it was found some control could be exercised over the flies without adversely affecting useful organisms. There was no important difference in the effects of D.D.T. and Gammexane on the larvæ of *Anisopus*, but D.D.T. was the more effective with *Psychoda*. A statistical examination of the observed results is now being carried out in conjunction with the Mathematics Division of the National Physical Laboratory with a view to the development of a programme of treatment which would prevent the occurrence of nuisance from flies during the whole of the breeding season.

It is characteristic of the complexity of modern industrial activity that D.D.T., which has proved such a useful agent in one sewage problem, should itself provide another. Waste acidic liquids from the first factory in this country which manufactured this compound caused damage to a sewage-disposal works, and, as a consequence, the Ministry of Supply asked the Board to undertake an examination of the whole problem. Conditions at various works have been investigated; at some, the somewhat expensive practice of conveying the waste liquor in tank wagons for discharge into the sea has been followed. The chemistry of the matter is complicated and cannot be dealt with here, but it is suggested at the end of the account which is given in the report that by controlling the conditions of absorption of waste chlorine in caustic soda a saleable solution of sodium hypochlorite could be produced and the discharge of toxic liquor to the sewers avoided. Other matters dealt with in the report concern further investigations carried out in connection with the manufacture of beet sugar, a subject on which the laboratory has already published much material; and experimental work carried out for the Ministry of Agriculture on the cleaning of mussels which have been cultivated in polluted waters. They can be dealt with by immersion for about 20 hours in sea water sterilised with bleaching powder.

* *Report of the Water Pollution Research Board for the year* 1946. H.M. Stationery Office. [Price 1*s.* net.]

NOTES.

DAVY-FARADAY EXHIBITION, PARIS.

MANY persons in this country will remember the interesting and well-presented exhibition on the life and work of Louis Pasteur, which, after a period at the Palais de la Découverte, Paris, was transferred to London and shown at the Science Museum, South Kensington, London, S.W.7, from September to November, 1947. The authorities in Paris now wish to pay tribute to the life and work of Davy and Faraday, and an exhibition is to be staged, again at the Palais de la Découverte (which operates under the ægis of the University of Paris), with the close collaboration and support of the Royal Institution, the Institution of Electrical Engineers, and the Science Museum. The Royal Institution have lent some of the original apparatus and laboratory equipment used by Sir Humphry Davy and by Michael Faraday, and have also sent many Davy and Faraday manuscripts, letters, and other relics. The Institution of Electrical Engineers have loaned a number of Faraday manuscripts from their archives, including his chemical notes and some letters. In addition, the Institution have lent the full-sized reproduction of the statue of Faraday which is in their possession; the original stands at the head of the main staircase in the Royal Institution building. The help of the authorities of the General Post Office has also been secured and they have sent to the promoters of the exhibition in Paris a working section of an automatic telephone exchange, which was recently shown at Radiolympia. With the collaboration of the British Council, arrangements have been made for a number of lectures on the life and work of Davy and Faraday to be delivered by British scientists and engineers. One of these lectures, on "The Industrial Consequences of Michael Faraday's Discoveries," will be given by Mr. J. F. Shipley, M.I.E.E., who has been deputed to be the representative of the President of the Institution of Electrical Engineers. The exhibition will be opened on May 20, and, we understand, will remain open for about three months.

RADIOACTIVE ISOTOPES.

Although much of an indefinite nature is talked and written about the application of atomic energy to the production of mechanical power, the only constructive service, as far as is known, that has been rendered by the developments having their origin in purely destructive intentions, is concerned with the production of radioactive isotopes. It has been suggested that the potential service of these bodies to scientific and material progress is so great that the possibility of manufacturing them on a large scale may ultimately prove to be worth the 600*l.* million spent in the United States on atomic-energy research, quite apart from any question of its military value. Radioactive isotopes are produced at the Oak Ridge plant in Tennessee, which is operated for the Atomic Energy Commission under the auspices of the University of Chicago. It is stated that more than 100 varieties of radio isotopes have been produced. Many of this number have probably been produced only on an experimental scale for investigational purposes, but selected isotopes have been manufactured on a substantial scale. Since August, 1946, when distribution commenced, up to last March, 2,200 deliveries of isotopes had been made to research workers in the United States. In September, 1947, it was announced that supplies could also be furnished to other countries, and since that time Australia, Great Britain, Canada, Italy, New Zealand, Argentina, the Netherlands, Denmark, Peru, Cuba, France, Belgium, the Union of South Africa, Sweden, Eire and Switzerland have made arrangements to receive and utilise them. Up till last March, shipments had been made to Australia, Argentina, Great Britain, Denmark, Peru, Canada, Italy and Sweden. Radiophosphorus has been exported on the largest scale and has gone to six out of these eight countries. It is used mainly in medical therapy for treatment of serious blood diseases, but has also been employed in fundamental studies of plant growth and in investigations on the disposition of phosphorus in bones and teeth. Radioactive iodine has been sent to four of these countries for the medical treatment of thyroid disorders, and isotopes of carbon, sulphur, zinc, iron and cobalt, have been supplied for work in chemistry, physics, biochemistry, physiology, and botany. It has been arranged that applicant countries for isotopes shall undertake to supply progress reports on the results of investigations at intervals of six months. Isotopes are shipped in stainless-steel cylinders protected by lead sheaths, but difficulty is being experienced in some cases in obtaining overseas air transport, some lines fearing interference with navigation instruments. The same difficulty was at first experienced in connection with domestic distribution in the United States, although all packages are carefully tested for surface radiation before dispatch. The matter is of importance, as some isotopes lose half their activity in a relatively short time and prompt handling is imperative.

EDUCATIONAL REQUIREMENTS FOR ELECTRICAL CORPORATE MEMBERSHIP.

It is announced in the April issue of the *Journal of the Institution of Electrical Engineers* that the Council has endorsed the opinion of their Membership Committee that, in future, all candidates for associate membership should be required to pass the appropriate examination, to hold a recognised exempting qualification or, in approved cases, to present a satisfactory thesis. The authority, which the Committee has hitherto possessed of recommending that in the case of certain candidates for associate membership of over 50 years of age, examination might be waived, is accordingly withdrawn. In commenting on this change of procedure in an editorial article in the *Journal*, it is recalled that satisfaction of the examination requirements by all candidates was insisted upon prior to 1916. In that year, owing to war conditions, the examination was temporarily abandoned and power to waive the requirements was taken. Six years later the examination was re-established, although power to dispense with it in exceptional cases, where the candidate was over 35 years of age was retained. In 1927, the age limit was raised to 40 years, and in 1944 to 50 years. The Membership Committee, however, have always found it difficult to apply the rule in practice, as exemption could be granted only in exceptional cases where the candidate was manifestly qualified in regard to fundamental knowledge. Moreover, since the Institution received its Royal Charter, nearly 27 years ago, the opportunities of acquiring higher technical education have increased greatly. As a result, the proportion of candidates with acceptable academic qualifications has steadily risen; and it is considered that, in fairness to these men, the examination requirements should therefore be applied to all entrants. In coming to this decision, full consideration has been given to its consequences. It is not thought that it will impose serious hardship on the older candidates, as they will generally be permitted to submit a thesis; and will thus be able to draw on their store of engineering experience in order to secure admission to corporate membership.

ONE HUNDRED YEARS OF ELECTRIC LIGHTING.

An exhibition to mark 100 years of research and achievement in electric lighting, which has been arranged at the Science Museum, South Kensington, London, S.W.7, was visited privately by H.M. the King on Thursday, April 29, and was opened to the public on the following day. It will remain open until the end of September. Those conversant with electric lighting may be forgiven if they find it difficult to allocate any outstanding event in its history to 1848. It was, however, in that year that Swan made his first experiments with carbon filaments. Earlier (in 1810) Davy had produced an electric arc between carbon rods, using current from a 2,000-volt battery. An arc lamp supplied from a Holmes generator was installed for the first time in the South Foreland lighthouse in 1858. The invention of the vacuum pump by Sprengel in 1865, no less than Faraday's discovery of the principle of electromagnetic induction in 1831, played a great part in subsequent development, of which the exhibition provides many striking examples from the 10-kW lamp for lighthouses to the bronchoscope lamp, which has a loading of about 0·5 watt. A multi-anode air-cooled discharge lamp is another novelty, as are the xenon-filled lamps developed by Aldington last year and the micro-second flash tube in which intensely brilliant flashes of very short duration can be produced by means of a special triggering circuit. The exhibition, however, is entirely electrical, but claims to tell the whole history of man-made illumination. For this purpose it is organised in a number of sections, the first of which is devoted to primitive forms of lighting, while in the second and third, apparatus and a series of dioramas show the rapid progress in the use of all forms of artificial illuminants that has been made during the past 100 years. The story of the electric filament lamp is illustrated in great detail; and this is followed by similar information regarding the fluorescent discharge tube. The increased illumination and greater working efficiency of the new lighting, together with examples of its numerous applications, are shown in the next three sections. An excursion is then made into the future and the possibilities inherent in the application of electric lighting to architecture are illustrated. Finally, a full size model of a coal face, illuminated by fluorescent lighting, can be inspected. In connection with the exhibition, a booklet, entitled "Darkness into Daylight," has been prepared by Mr. W. T. O'Dea and is published by H.M. Stationery Office at the price of 1*s.* It gives an excellent account of the past, present and future of man-made illumination and is well worth study.

TIDAL MODEL OF FIRTH OF FORTH.

The approach channel to H.M. Dockyard, Rosyth, in the Firth of Forth, is dredged about every two or three years to prevent it silting up. The nature of the flow of water which causes this silting up may be observed in a tidal model of the Forth which is now in use at the National Physical Laboratory, Teddington. Construction of the model was commenced about two years ago, at the instigation of the Admiralty, and it has been in use for a year. No results are available for publication at this stage, however. The model was originally the responsibility of the Engineering Division of the N.P.L., but it was taken over by the Hydraulics Research Organisation of the Department of Scientific and Industrial Research, when that body was formed last year. It is approximately 80 ft. in length, and 18 ft. wide at the tide-making end. The Forth, from Stirling to the line of the Leith-Burntisland ferry, is represented to a horizontal scale of 1 : 1,800, or about 3 ft. to the mile. By making the seaward boundary of the model at a point well below the Dockyard and the Forth Bridge, the effects of the tide-making plunger are eliminated before the flood tide reaches the region of the Dockyard. The Forth proper is tidal as far upstream as Stirling, although there are several severe loops below there. The vertical scale is 1 : 144, and the horizontal velocity scale is 1 : 12. The tidal period in the model (from one high water to the next) is about 5 minutes, representing 12·4 hours. Approximately 4 tons of sand were used in constructing the model. When we visited the laboratory on Wednesday, May 5, the model was in use; the fresh-water flows of the Forth and other rivers which discharge into the estuary were being simulated, and the quantity of water in the model was maintained constant by discharge over a coned-funnel weir, which was raised and lowered automatically in relation to the movement of the tide-making plunger. In conjunction with observations which are being made at the Firth, the velocity distribution in the model, in the region of the Dockyard, is being studied. The influence of new structures, and possibly of a "pitched" island, on the silting up of the channel, will then be examined.

ALUMINIUM DEVELOPMENT ASSOCIATION.

The present headquarters of the Aluminium Development Association, at 33, Grosvenor-street, London, W.1, were acquired in December, 1946, and were furnished, fully equipped and occupied by the middle of March, 1947, the move from 67, Brook-street having been effected without disloca-

tion of the Association's affairs. The annual report of the Association for the year ended December 31, 1947, is thus largely a record of the first year in their new headquarters. At four meetings held during the year, the Research Committee have followed the policy previously agreed, that the Association should undertake research only of an *ad hoc* nature, and when no other bodies are able to carry out the required investigations which, in all cases, must be directed towards further development. The Building Sub-Committee of the Association met seven times during the year and dealt with many topics, including the draft British Standard Specification for aluminium rainwater goods, problems involved in the use of aluminium alloys for the structure and covering of roofs, aluminium windows, and aluminium-alloy scaffolding. The Marine Sub-Committee met on six occasions and discussed questions relating to the supply of large plates and sections suitable for shipbuilding. An investigation into the buckling of ship's plates has been completed. The Transport Sub-Committee met seven times during the year and their work was devoted chiefly to railway applications; information on cattle wagons, refrigerated containers, covered-wagon bodies and coaching stock having been provided. The Library and Information Department have continued to supply data directly to external inquirers and to members of the staff, and, during the year, there were 1,260 additions to the library, bringing the total of books, brochures, etc., available, to more than 5,000. Moreover, 36 lectures, usually illustrated with slides or films, were given by the staff.

Congestion on the Underground.

The congestion on the Underground during rush hours was one of the topics discussed at a meeting held on Tuesday, April 27, between the chairman of the London Transport Executive, Lord Latham, with his principal technical officers, and representatives of the technical Press. In reply to questions, it was stated that the extension of, for example, the Central Line, eastwards and westwards, would not necessarily increase the load on it in the central area. It would simply mean that passengers could travel all the way from the outer suburbs by London Transport, instead of travelling first by a main-line train to, say, Liverpool Street, and then changing on to the Underground. During peak traffic periods, when trains were run at intervals of 1½ minutes, it was essential for stops at stations to be not more than about 30 seconds. If one train were delayed, an excessive number of passengers would accumulate at the next station, and this would delay the train even more. This fundamental difficulty could be partly overcome by providing two station platforms for each line. An example of this arrangement was to be seen at Baker Street station, but, for various reasons, it would not be possible to do this at every station where congestion occurred. Some improvement had been effected by installing a new type of signalling which allowed a train to continue moving, and to approach closer to a station, while the train ahead was standing in that station. With this signalling, which is dealt with on page 450, of this issue, it was possible for trains to stand for 48 seconds. The stations on the Central Line had been extended to accommodate eight-car trains. That was not necessarily the limit in this direction, but, it was not certain that rather than extend stations to take ten-car trains, it would not be better to construct new tubes, if capital were available. On the road transport side, they were undertaking experiments with infra-red apparatus to enable omnibus drivers to see farther in fog.

Sir Amos Ayre Prize.

Particulars have now been issued, by the Council of the North-East Coast Institution of Engineers and Shipbuilders, of the regulations governing the award of the Sir Amos Ayre Prize, which was founded by Sir Amos Ayre, K.B.E., Hon. Fellow of the Institution, for the purpose of encouraging study to develop useful empirical formulæ in connection with ship resistance and ship propulsion. More especially, it was the founder's desire to develop formulæ which would provide a simple and rapid means of approximating, for a given hull form and sea speed, the propulsive coefficient "at the propeller," as distinct from the more familiar propulsive coefficient represented by effective horse-power divided by indicated horse-power. The subject is one to which Sir Amos has devoted attention in several papers delivered before the Institution, notably one in vol. 44 of the *Transactions* (1927-8), another in vol. 49 (1932-3), and a third in vol. 61 (1944-5); and the data given in the two papers of 1927 and 1932 have been made available, under the title of "Approximating E.H.P.," in an excerpt from the *Transactions*, for the information and guidance of intending candidates for the Prize. The regulations provide that the Prize shall be awarded for any paper, read and discussed before the Institution and published in the *Transactions*, which, in the opinion of the Council, sufficiently advances knowledge in respect of the approximate evaluation of effective horse-power, shaft horse-power or propulsive coefficient "at the propeller." The award is to be made not oftener than biennially and will consist of a sum of money equivalent to the accrued interest on the invested fund over a period of not less than two years; this, we understand, represents a minimum sum of 20 guineas. As, at present, the subject of approximate effective horse-power is held to have been covered sufficiently by Sir Amos Ayre's own papers, contained in the excerpt mentioned above, intending competitors for the award will be required to give their attention to the problems of propulsive coefficient and shaft horse-power. Competition for the Prize is not confined to members of the North-East Coast Institution; and, should it not be awarded in any two-year period, the income thus unexpended may be used entirely or in part, at the discretion of the Council, either to increase the amount of a subsequent Prize, or to provide a subordinate prize, or as an addition to the capital of the Award Fund. Copies of the regulations may be obtained on application to the secretary of the North-East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-on-Tyne, 1.

LETTER TO THE EDITOR.

OUTPUT AND EFFICIENCY OF GAS TURBINES.

To the Editor of Engineering.

Sir,—It is gratifying to me, as one of the early pioneers of the gas turbine in the United States (my initial efforts in this field date back a quarter of a century), to witness what appears to be a noticeable revival of interest in this promising type of prime mover, as shown, among other things, by recent reprints in Engineering of important papers on the subject. May I be allowed to make a few remarks? In his English paper of 1939, Dr. A. Meyer, of the Brown, Boveri Company, gives two diagrams (Fig. 5, page 201, volume 141 (1939) of the *Transactions of the Institution of Mechanical Engineers*) which show the net output and efficiency of a gas-turbine plant as a function of two parameters: (1) the initial temperature of the power gas striking the buckets; and (2) the product of the turbine and compressor efficiencies.

Now, this is a usual way of presenting the physical processes involved; for while it is possible, under duress, to describe the phenomena by means of two parameters only, the more natural way consists in expressing the facts in terms of four distinct parameters, not reducible to each other. From the point of view of the practical engineer, the initial temperature of the gas is a most important factor, since it governs the choice of materials and of the allowable stresses, but physically, the gas temperature enters the situation in an indirect way only. In addition, Dr. Meyer's presentation fails to bring to light another most fundamental factor, namely, the ratio between compressor and turbine work. The importance of this parameter was recognised and duly pointed out in a paper written by the undersigned jointly with Professor L. S. Marks, then both of Harvard University, and read before the American Society of Mechanical Engineers at New York in December, 1924.

The conclusions of this early paper can be extended to show that the ratio of compressor to turbine work is the most important factor of the process under discussion, in the sense that the net output of a gas-turbine plant (whether operating on the constant-pressure or constant-volume cycle) will be nil if this ratio exceeds a certain value. This statement holds irrespectively of gas temperature, values of the efficiencies, or any other pertinent factor.

In order to see this, consider the net output W of a gas-turbine plant

$$W = E_t \eta_{t_1 R} - \frac{E_c}{\eta_{c_1 R}}. \quad . \quad . \quad . \quad (1)$$

E_t being the adiabatic drop in enthalpy in the turbine, E_c the adiabatic rise in enthalpy taking place in the compressor, and $\eta_{t_1 R}$, $\eta_{c_1 R}$ the turbine and compressor Rankine efficiencies, respectively. Introducing Dr. Meyer's factor $\eta = \eta_{t_1 R}\,\eta_{c_1 R}$ as well as the ratio $r = \frac{E_c}{E_t}$, we obtain

$$W = E_t \eta_{t_1 R}\left(1 - \frac{r}{\eta}\right). \quad . \quad . \quad . \quad (2)$$

Dividing this by the amount Q of heat supplied by the combustion of the fuel and noting that

$$\frac{W}{Q} = \eta_0\,; \quad \frac{E_t \eta_{t_1 R}}{Q} = \eta_{t_1 0},$$

where $\eta_{t_1 0}$ and η_0 are the turbine and plant overall, or shaft, efficiencies, respectively, we can write

$$\eta_0 = \eta_{t_1 0}\left(1 - \frac{r}{\eta}\right). \quad . \quad . \quad . \quad (3)$$

or

$$f(\eta_1\,\eta_0,\,\eta_{t_1 0},\,r) = \frac{\eta\,\eta_0}{\eta_{t_1 0}} + r - \eta = 0. \quad (4)$$

The last expression (which can, of course, be thrown into a variety of equivalent forms) may be called the basic energy equation of the gas-turbine plant. It is seen from it that: (1) the performance of the plant depends upon four non-dimensional parameters, to wit: η_1, η_0, $\eta_{t_1 0}$, r. These are not interdependent; (2) the maximum temperature of the products of combustion does not enter into the basic energy equation explicitly; (3) the necessary condition for the production of useful work by the plant as a whole ($\eta_0 > 0$) is that $r < \eta$ (provided, of course, that the trivial condition $\eta \neq 0$ is satisfied) and this regardless of any other feature of the thermodynamic cycle (such as compression pressure, character of the combustion, amount of excess air, type and extent of cooling, etc.).

Stated in words: production of useful work is not possible unless the ratio of the adiabatic changes of enthalpy of the compressor to that of the turbine is less than the product of the Rankine efficiencies of the compressor into that of the turbine. The maximum temperature of the products of combustion enters the energy equation only in so far as, for a given pre-compression pressure, a higher terminal combustion temperature corresponds to a lower value of r. The desire to lower this value as much as practicable has led Holzwarth to the development of the constant-volume gas turbine, the possibilities of which (for jet propulsion of aircraft, among others) are not yet exhausted. By the introduction of the parameters

$$p_1 = \frac{\eta_0}{\eta_{t_1 0}},$$

and

$$p_2 = \frac{r}{\eta}, \quad . \quad . \quad . \quad . \quad . \quad (5)$$

the basic energy equation is reduced to a two-parameter (and less suggestive) form

$$p_1 + p_2 = 1.$$

Yours faithfully,

M. Daniloff.

Massachusetts Institute of Technology,
Cambridge, Mass., U.S.A.
April 13, 1948.

Institution of Metallurgists.—The fourth annual general meeting of the Institution of Metallurgists will be held at the offices of the Institution, 4, Grosvenor-gardens, London, S.W.1, on Thursday, June 10, at 3 p.m.

ENGINEERING AT CAMBRIDGE UNIVERSITY.

In view of all that has been said and written, since the end of the war, about the need for greatly increased numbers of trained technicians and the important part which the universities are expected to play in educating them, a wider than academic interest attaches to the report for the year 1946-47 of Professor J. F. Baker, who is head of the Department of Engineering at the University of Cambridge. The outstanding feature, alike of the report (the full text of which appeared in the *Cambridge University Reporter* of April 27) and of the activities that it describes, is the markedly greater amount of attention now devoted to scientific research as compared, for example, with the years immediately succeeding the 1914-18 war. The number of undergraduate students, on the other hand, is—somewhat surprisingly—nearly 150 less than the peak figure reached during the Michaelmas Term of 1920, the disparity being accounted for partly by the large number of men taking special or short courses in 1920, but partly also by a present limit of about 120 on the number of students in any one class. Despite restrictions, 270 new students were admitted during the year, bringing the total of engineering undergraduates up to 658, of whom no fewer than 574 were reading for honours. It is noteworthy that the honours students in 1947 were numerically greater, and proportionately much greater, than was the case in the comparable year 1921. The Tripos examiners found, however, that many candidates were not, in fact, of honours standard; and in future more undergraduates will be advised, on the results of a new two-part qualifying examination, to enter for a new Engineering Studies course which will provide a training more suited to their abilities than the Tripos course.

The resumption, in 1946, of three-year courses, and the institution of a new Part II of the Tripos, have entailed a considerable increase in the number of lectures and laboratory classes, and a corresponding strain on teaching accommodation and staff. The re-equipment of workshops and laboratories made some progress during the year, and some increase of accommodation was achieved; but until extensive building additional to the workshop block can be undertaken, both teaching and research must be restricted.

Despite such difficulties, 23 engineering research students were at work during 1946-47, as compared with only three in 1920-21, and several members of the teaching staff, whose work had been interrupted by the war, resumed their researches. The outcome is an impressive programme of investigations, embracing a wide range of laboratory-scale engineering, the subjects of which deserve to be widely known throughout industry and are of especial interest to research workers along similar lines elsewhere. A noteworthy feature of the work as a whole is the attention given to problems involving fluid motion, indicating the importance of fluid mechanics in modern technology and perhaps reflecting the influence of a division of the Engineering Department which specialises in aeronautics. Within this sub-department itself, a study is being made of the aerodynamic reactions and other characteristic effects when the boundary layer is sucked through a solid porous surface immersed in a moving airstream. A new wind tunnel has been designed and constructed for investigating two-dimensional flow problems, but, since many aerodynamic effects on aircraft wings can as yet be ascertained only from experiments in very large tunnels, work is in progress to enable wing characteristics to be predicted theoretically by taking account of boundary layers, with recourse at most to experiments on a relatively inexpensive scale.

Incidental applications of aerodynamics are exemplified by gas-turbine research, in which boundary-layer phenomena are under investigation for the flat surfaces of diffusers and the curved surfaces of the blades of an axial-flow air-compressor cascade. The effects of blade camber and inlet air angle on the pressure distribution around the profiles of a cascade of blades, and on the deviation of the air flow, are being explored over a range of Reynolds Numbers. The repercussions of aerodynamics on structural design are represented by an experiment with a 14-ft. sailing boat, which has been fitted with stress recorders so that the components of the wind forces on the sails can be measured.

In addition to the aerodynamic aspects of gas-turbine design, the feasibility of various internal-combustion turbine cycles for marine propulsion have been examined theoretically, with special reference to efficiency and performance at part loads. It is significant of modern ideas that the only research connected with the steam engine is a somewhat academic study of regenerative steam-cycle theory. The remaining heat-engine research has been directed to some outstanding problems of reciprocating internal-combustion engines. In one of these investigations, a very small photo-electric element is being used to indicate the progress of the scavenging process. In another, the excessive "blow-by" leakage of gas past the piston rings, commonly occurring above a critical engine speed, has been traced to vibratory movements of the piston rings in their grooves, which have been electrically recorded in a small petrol engine running under its own power at speeds up to 5,500 r.p.m.

Among a variety of other mechanical problems, one of exceptional interest, as having been solved by operational mathematics, concerns the stresses caused by a suddenly applied load on a beam supported in various ways. Theoretical stresses have been verified experimentally and an electromagnetic device has revealed the velocities with which the beam deflects under impact. Model experiments on the lateral movements of a pair of railway wheels on one axle have shown the influences of unsprung mass, wear of rails and tyres, flange clearance and lateral track stiffness, on the incidence of oscillatory "hunting." Experimental wire-drawing equipment has been used for ascertaining the effects of alternative lubricating procedures on the relationship between the work usefully expended in deforming the wire and that wasted in friction. The lubrication of gears is the subject of a comprehensive new research, while the dynamic stresses in gear teeth are to be studied concurrently by photo-elastic apparatus incorporating a stroboscopic source of intense monochromatic light. Experiments with water-lubricated journal bearings have revealed such small frictional torques that no advantage from the use of bearings of the centrally-pivoted tilting-pad type can be expected.

Engineering materials and structures have long figured prominently among the researches at Cambridge, and it is worth while to recall the important work on the notch-brittleness of iron and mild steel, with special reference to temperature effects, which has been in progress for some years in connection with structural failures of welded ships. More recently, the Engineering Department has collaborated in the analysis and interpretation of stress data obtained during the Admiralty's trials of comparable full-sized ships of welded and riveted construction. A mathematical analysis of the behaviour of a flat plate, simultaneously subjected to forces in its plane and to transverse loading, represents a further contribution to shipbuilding. Rigidly jointed steel-framed structures are under investigation from the special standpoint of true load-carrying capacity, and a variety of structural members and fabricated assemblies have been studied in the range of plastic deformation and collapse under static loading. A start has been made, for the case of a single-bay rectangular portal frame, in developing a method of design such that a redundant structure shall collapse at a prescribed load. Similar research on plastic design, concerned with the lateral instability of steel beams that have yielded partly in flexure, is supported by theoretical analyses of the dependence of flexural and torsional rigidity upon the degree of plasticity due to primary flexure, and of the relation between lateral instability and loading arrangements in beams of rectangular cross-section.

Somewhat similar work has been carried out on the lateral instability of light-alloy beams and the general behaviour of light-alloy structures within the plastic deformation range. For engineering components subject to internal pressure, however, research has been restricted to the elastic range; and the particular case of drumheads, such as are used in boilers and some autoclaves, has been analysed, as regards stresses and deflections, both mathematically and with the aid of mechanical analogue apparatus. Good agreement with published experimental results has encouraged the extension of the work to complete ranges of industrial drumheads. The allied problems of stress distribution in welded pipe bends has been studied experimentally by means of electrical resistance strain gauges in conjunction with strain-indicating lacquer, leading to the important general conclusion that steel pipe bends, like other ductile structures, can carry loads far in excess of that which first produces yield at the most highly stressed fibre. Compressive loading tests have confirmed the commonly assumed distribution of stress in a pipe bend, but have shown that the actual stresses are generally much greater than those indicated by theory, the greatest individual strain measured being in the transverse direction on the interior surface of the pipe. In a related field of inquiry, a method has been developed for calculating stress and strain due to internal pressure in a thick tube of material having any known stress-strain relation. A general study of the distribution of stress and strain in materials which do not obey Hooke's Law is in progress by means of a testing machine capable of applying direct load and torque, and provided with means for subjecting tubular specimens to internal pressure. The effects of high rates of straining on the yield strength of mild steel, and of low rates of straining on the tensile properties of high-purity aluminium and other metals, are also under investigation.

Electrical research, it is significant to note, has been devoted almost exclusively to electronic subjects, among which one of great complexity aims at enabling the results obtained from the "electrolytic tank" method of solving Laplace's equations to be presented, by means of servo-mechanisms, in the form of three shaft rotations, so that direct coupling to a differential analyser becomes possible. The primary purpose in view is to reduce the computation entailed in deriving electron trajectories, and it is hoped, by modifying the analyser, to correct the trajectories for the effects of space charge and relativity. Novel apparatus in course of development includes a mass spectroscope which indicates different types of gaseous ions as pulses on a cathode-ray oscilloscope; and an electrostatic electron microscope for studying special types of electron lenses and the general technique of electron microscopy. The operation of a klystron on a harmonic of its normal frequency is one possible outcome of a research into the modulation of an electron beam passing through a cavity resonator, excited by power from an external source. The reduction of shot noise, in thermionic valves and other devices, by space charge has been the subject of an investigation into the behaviour of specially-constructed valves.

Brief reference must be made, finally, to some preliminary work on soil mechanics, one aspect of which has entailed the production of apparatus for determining the shear strength of clays incorporating remoulded kaolinite and bentonite. A highly practical experiment is also in progress to measure the component soil forces on a simple tillage implement in motion. The difficulties of getting such delicate instruments as wire-resistance strain gauges and deflection indicators to function reliably when literally "in the field," are formidable, but a continuously recording 12-channel electromagnetic oscillograph has been specially developed for the purpose and has undergone some searching trials. This particular research has the support of the Nuffield Foundation: several of the other investigations referred to have been sponsored or financially supported by industrial research associations, Government departments, or the research departments of private commercial undertakings. It is clear, therefore, that, despite hampering restrictions on staff and buildings, the Department of Engineering is contributing substantially to the output of new technical knowledge. Equally evident is the recognition by the staff that flourishing research is a proper function of a university as well as an essential background to the best type of undergraduate training.

THE IRON AND STEEL INSTITUTE.

THE seventy-ninth annual general meeting of the Iron and Steel Institute was held at the Royal Institution of Chartered Surveyors, Great George-street, London, S.W.1, on Wednesday and Thursday, May 5 and 6. The chair at the outset of the first day of the meeting was occupied by the President, Dr. C. H. Desch, F.R.S. The minutes of the previous meeting, held in London on November 12 and 13, having been dealt with, Dr. Desch referred to the loss which the industry and the Institute had sustained by the death, on December 16, 1947, of Mr. Benjamin Talbot, a Bessemer Medallist and past-president of the Institute.

REPORT OF COUNCIL.

The Report of the Council for the year 1947 was then presented. It showed that the number of members on the roll of the Institute on December 31, 1947, was 4,522, an increase of 478, or 12 per cent., over the record figure of the previous year. The Council recorded with regret the deaths of 37 members which had occurred during the year; these included, in addition to Mr. Benjamin Talbot, Dr. J. W. Donaldson and Dr. A. H. Jay, and also Mr. F. P. Clarke, Mr. F. W. Cooper, Mr. J. P. Davies, Mr. G. Lewis, Captain J. F. Luckman, Mr. J. S. G. Primrose and Colonel J. S. Trinham. The last seven had been members for forty years or more. Collaboration with the British Iron and Steel Research Association had been extended and was believed now to be firmly established in the mutual interests of both organisations. Arrangements for separating the staffs and secretaryships of the Institute and the Institute of Metals had been carried through, and very friendly relations maintained with that Institute and with the Institution of Metallurgists. Collaboration with affiliated local societies and important metallurgical institutions overseas had been extended to additional societies. The post-war programme for re-organising the library and information services had been continued. The work of the Joint Committee on Metallurgical Education (on which the Institute was represented, and for the secretarial arrangements of which it was responsible) and of the Institute's Education officer, had continued. Professor Leslie Aitchison had succeeded Dr. C. H. Desch, F.R.S., as chairman of the Committee, which had been strengthened by co-opting representatives of industrial companies. Satisfactory progress had also been made in the development of the scheme for awarding National Certificates in Metallurgy.

REPORT OF HONORARY TREASURER.

The statement of accounts submitted by the honorary treasurer, the Hon. R. G. Lyttelton, showed that the year's operations had resulted in an excess of expenditure over income of 6,682*l.*, the total expenditure for the year being 34,002*l.* Salaries, of 20,361*l.*, reflected the cost of the first full year of operating the post-war programme of development. Other items of expenditure were 1,662*l.*, on rent, lighting, heating and cleaning; 1,490*l.* on publishing, 2,004*l.* on meetings and travelling, and 3,365*l.* on stationery, postage and other office expenses. The income from members' subscriptions amounted to 10,879*l.*, and that from companies' special subscriptions to 3,884*l.* The grant from the British Iron and Steel Research Association was 11,681*l.*, excluding the payment of the cost of publishing on behalf of the Association, namely, 4,748*l.*

MEDALS AND AWARDS.

Dr. Desch then presented the Bessemer Gold Medal, for 1948, to Mr. W. J. Dawson, C.B.E., formerly of Hadfields Limited, in recognition of his contributions to the development of steel castings and to the production of alloy and heat-resisting steels. In doing so, the President stated that Mr. Dawson had been associated all his life with the Sheffield steel industry. He had been one of the early students of the late Professor J. O. Arnold and, as a young man, was awarded the Associateship in Metallurgy of the institution now known as the Applied Science Department of the University of Sheffield. After serving on the staff of Messrs. Henry Bessemer and Company, Limited, for three years, he entered the laboratory of Messrs. Hadfields Limited, Hecla Works, Sheffield. Shortly afterwards he was put in charge of the steelmaking department of the Hecla works and for nearly half a century had been closely linked with all metallurgical developments of the firm. Mr. Dawson had taken a leading part in co-operative research, particularly during the late war, when he had served as chairman of the Technical Advisory Committee of the Special and Alloy Steels Committee (Steel Control, Ministry of Supply), and as a member of the Metallurgy Committee of the Advisory Council on Scientific Research and Technical Development. He was chairman of the Tanks Cast Armour Committee and a member of the Tanks Wrought Armour and Aircraft Armour Committee. He was awarded the E. J. Fox Gold Medal of the Institute of British Foundrymen, for 1940, in recognition of his work as chairman of the Steel Castings Research Committee. In returning thanks for the honour conferred upon him, Mr. Dawson mentioned that soon after his appointment to Messrs. Bessemer, a boy, fresh from school, had joined the staff of the firm. This boy, who was later to make his mark in the realm of metallurgy, was W. H. Hatfield.

Dr. Desch then presented the Sir Robert Hadfield Medal, for 1948, to Mr. A. Preece, of the University of Leeds, in recognition of his researches on the overheating and "burning" of steel. The President's final presentation was that of the Williams Prize, for 1947, to Mr. R. Fowler, blast-furnace superintendent to Messrs. Richard Thomas and Baldwins Limited, Ebbw Vale, for his paper, entitled "Blowing-out a Blast Furnace."

CHANGES ON THE COUNCIL AND ANNOUNCEMENTS.

The secretary then announced that since November, 1947, Mr. T. Jolly had been appointed a member of Council and that, during their period of office, the following were to serve as honorary members of the Council: Sir Arthur Smout, as President of the Institute of Metals, in place of Colonel P. G. J. Gueterbock; Dr. C. Sykes, F.R.S., as President of the Sheffield Metallurgical Association, in place of Mr. T. F. Russell; Mr. B. W. Doncaster, President of the Sheffield Society of Engineers and Metallurgists, in place of Mr. Ambrose Firth; Mr. Hemingway Jones (who had since been succeeded by Mr. H. F. Padbury) as President of the Ebbw Vale Metallurgical Society; and Mr. A. Preece while serving as President of the Leeds Metallurgical Society. Furthermore, in accordance with by-law 10, the three vice-presidents, namely, Mr. J. R. Menzies-Wilson, Mr. J. Mitchell and Mr. R. Mather, and the five members of Council, Mr. I. F. L. Elliot, Mr. C. R. Wheeler, Mr. E. F Law, Dr. C. Sykes, and Mr. D. A. Oliver, who, as announced at the Autumn Meeting in 1947, were due to retire in rotation, were now declared to be re-elected, no other nominations having been received. The President then announced that the autumn general meeting of the Institute would be held in London on November 10 and 11, 1948. Dr. Desch also announced that an invitation to hold a summer meeting in Norway next year had been received and, in all probability, the Institute would leave this country on June 25 and return on July 9, 1949.

INDUCTION OF NEW PRESIDENT.

At this stage of the proceedings, Dr. Desch inducted the President-Elect, Sir Andrew McCance, D.Sc., LL.D., F.R.S., into the chair. In doing so, he stated that in Sir Andrew was represented that somewhat rare combination of a successful business manager and a distinguished scientific investigator. Sir Andrew was deputy chairman and joint managing director of Colvilles Limited, and a director of other companies. He was elected an F.R.S. in 1943, was the first chairman of the British Iron and Steel Research Association, and was knighted in June, 1947.

After a vote of thanks to the retiring President had been proposed by Sir Andrew McCance and seconded by Sir Peter Brown, Sir Andrew delivered his presidential address, on "The Development of the Open-Hearth Furnace," with which we hope to deal in a future issue.

(To be continued.)

SPEED-CONTROLLED SIGNALLING AND SAND-TRAP TURN-OUTS.

Two interesting developments—one in signalling and the other in permanent way—have been introduced recently by the London Transport Executive. Speed-controlled signalling has been designed to allow a train to approach closer to another train held up in the station ahead, and a simplified form of sand-trap turn-out has been introduced to eliminate the gap in the running rail which is associated with conventional points.

The improved form of sand-trap turn-out is illustrated in Fig. 1, opposite. There are many places on London Transport lines where turn-outs leading to sand-traps are provided to protect converging junctions. The turn-out is used only on the very rare occasions when a train over-runs a signal at "danger," but every train that passes normally over the running line is jolted at the crossing. The new turn-out eliminates the gap in the running rail which causes the jolt. In Fig. 1, a train travelling normally over the running rails would come towards the observer, from the centre background to the left foreground, and it would not pass over a break in the rail. A train diverted on to the turn-out, however, would travel towards the right foreground, and its left-hand wheels (from the observer's point of view) would ride up the wing rail, which is inclined so that the flanges of the wheels will pass over the running rail. A falling ramp is fixed to the spliced rail (both butt against the outside of the running rail), to allow the wheels to run down smoothly on to the spliced rail which is laid at the normal level. The running rail is held by special chairs, and, as there is no gap in it, no check rail is required on the opposite rail of the through line.

By this means, the wear on a wing rail and nose of a normal crossing is eliminated. The drop of a wheel passing from the wing rail to the point rail of a conventional crossing is about $\frac{1}{4}$ in., and in some places 28 wheels pass every three minutes. The wear and tear reduce the life of the crossing considerably, but with the new arrangement wear at this place will be eliminated. It will not be necessary to pack the ballast so frequently, and the effect on the rolling stock also will be less detrimental. The side-tipping motion imparted to a vehicle diverted into the turn-out is unimportant.

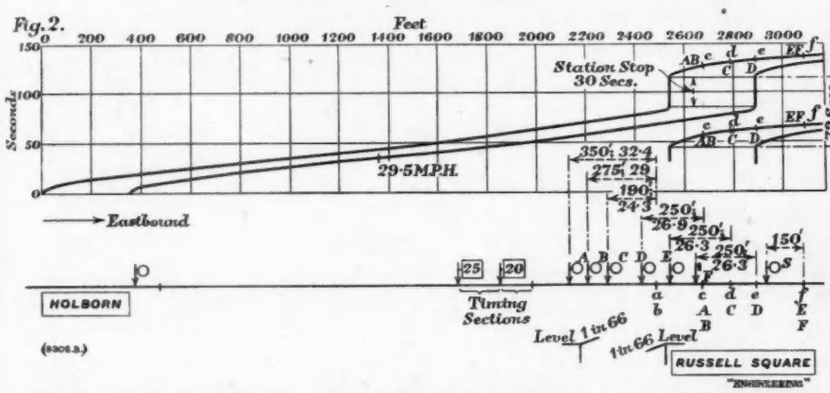
The traffic on the Piccadilly Line during rush hours has increased to such an extent that there is difficulty in maintaining a satisfactory service. Within the limits imposed by existing signalling apparatus, the maximum number of trains per hour is run. This depends on restricting station stops to 30 seconds, which is not always possible during rush hours. When a train stops for an unduly long time in a station, the following train is stopped at the "home" signal. Then, when the first train leaves the station and the home signal clears behind it, the second train has to start from rest to draw into the station, and thus a further delay is imposed. This type of delay can rapidly react on several trains. Furthermore, at a busy station, passengers are continually arriving at the platform, and when a train arrives late a further delay is likely to be imposed by the time taken for an excessive number of passengers to board the train. It was decided therefore to install a system of speed-controlled signalling on the busiest section of the Piccadilly Line, between Green Park and King's Cross.

The function of this type of signalling is to enable the driver of a train which is approaching an occupied station to reduce his speed earlier, and to approach closer to the station than he would do otherwise, thereby ensuring that when the train ahead draws out of the station his own train is still moving, although at a reduced speed, and he is able to pull into the station without the delay which would occur if he had been brought to a stop. This facility is all the more important because the Underground tracks have been laid generally with an up gradient into stations and a down gradient out of stations, to assist, by gravitation, the starting and stopping of trains. With existing signals, trains can be run at intervals of $1\frac{1}{2}$ minutes with station stops of 30 seconds, but with the new system the stops can be increased to 48 seconds. The first installation has been brought into operation recently at Liverpool Street on the Central Line, and the arrangement proposed for the section of the Piccadilly Line between Holborn and Russell Square is shown in Fig. 2, opposite.

The movement of a train is indicated on the diagram by a pair of lines, one representing the head of the train, and the other representing the tail. At any particular instant, the train can be represented by a horizontal line, the length of which corresponds to the length of the train, according to the scale of the diagram. When the train is standing in a station, as shown on the right-hand side of the diagram, the train "line" moves vertically according to the time scale. The diagram illustrates the relative movement of two trains: the first is moving eastwards out of Russell

TRACK AND SIGNALLING IMPROVEMENTS.

FIG. 1. SAND-TRAP TURN-OUT.



Square station, after a long stop of 48 seconds, and is closely followed by the second, which has already travelled more than half-way from Holborn. The second train accelerates out of Holborn at 2·23 ft. per second per second up to 18·25 miles an hour, and then accelerates at a reduced rate up to 29·5 miles an hour. It then decelerates (for reasons which will be apparent when the signalling system has been described), and stops in Russell Square, where it remains for 30 seconds. The position of the approach gradient of 1 in 66 outside the station is shown on the diagram.

Five "home" signals, A, B, C, D and E, are provided. There is also a "train-stop" signal F near the middle of the platform. This is not a desirable position for a signal, because a train might be stopped by it, with half the train in the station and half out. Under normal conditions, a train is never required to stop at it, or be automatically tripped by it, but it is provided for the emergency when an outgoing train is stopped suddenly, before it has passed the starting signal S by a safe distance. If this situation were to arise, the following train would be checked by the "train-stop" signal F. For all normal purposes, however, the five principal home signals are A, B, C, D and E. Signal A is fixed at the full safety distance from the station for the normal full speed. It should, perhaps, be explained that the safety distance is that distance in which, if a train passes a signal at danger, the train will be brought to a stop by the automatic braking, due allowance being made for any gradient, etc. Signal C is fixed at a reduced safety distance, and signal B is fixed at an intermediate distance.

Two speed-restriction signs, 25 and 20 miles an hour, are provided in the tunnel. If there is no train in Russell Square, these signs are not illuminated, all the home signals are clear, and a train can run straight into the station. When, however, a train is standing in the station, all home signals, A, B, C, D and E, are at danger behind it, and the two speed-restriction signs are illuminated. The driver of a following train, on seeing the first—25-m.p.h.—sign, reduces his speed. At that sign, a short section of track circuit is connected to a time-element relay, and if the train passes over this section at a speed of less than 25 miles an hour the relay clears signal A. The driver must then reduce the speed of his train to below 20 miles an hour at the second sign, where a second timing section is provided. If he does this, the relay for the second section clears signal B, and he is able to pass signals A and B, and draw up to signal C. In the meantime, if the standing train moves out of the station, signals C, D and E will be cleared in turn, and the following train can draw into the station.

In Fig. 2, the home signals are indicated by the letters A, B, C, D and E, and the points on the line where the tail of a train clears each of these signals, regardless of the speed-control system, are also indicated by these capital letters along the base line of the diagram. The letters *a*, *b*, *c*, *d*, *e* and *f* indicate the points on the line where the tail of a train will release, but not clear, the corresponding signals for actuation by a following train which has reduced its speed correctly. Thus, with one train in the station, signals A and B only are free to be cleared by a following train which passes the timing sections at the reduced speeds. As the first train moves out, the signals C, D and E will be cleared in turn. The diagram also shows the length of "overlap" past each signal, i.e., the distance allowed for tripping a train which passes a signal at danger. Thus, "350′, 32·4" indicates an overlap of 350 ft., and a "maximum" speed of 32·4 miles an hour. This speed, in each case, is the maximum at which a train can pass the signal and yet be braked automatically in that distance. It will be seen that, with a reduced speed of 20 miles an hour, there is an ample margin of safety in every case. The "headway," or the difference between the times of departure of the two trains from Russell Square, is shown as 72 seconds, i.e., the first train remained in the station for 48 seconds—18 seconds longer than the normal time—but, owing to the operation of the speed-controlled signalling, the second train was not delayed. The system has been designed so that time-element relays, all with standard settings of 4½ seconds, are used in any location. The correct speed effect is obtained by choosing a suitable length over which the train has to run. The value of this arrangement is that there is no risk of an error creeping in when a time relay is renewed.

ANNUAL REPORT OF THE ELECTRICITY COMMISSIONERS.

THE 22nd annual report* of the Electricity Commissioners, which was published on April 19, covers the year ended March 31, 1947. It has therefore to be followed by a final document covering the period ending with March 31 of the present year, on which date certain of its functions fell to be dealt with by the Ministry of Fuel and Power and others became the responsibility of the British Electricity Authority. It is to be hoped that in the last report the opportunity will be taken to review operations during a period of nearly a quarter of a century when the electricity-supply industry made considerable progress and during which numerous difficulties had to be faced and overcome.

One of the greatest of these difficulties is dealt with in the present report. It arose, of course, from the necessity of securing the maximum possible restriction of demand at peak-load periods, owing to the shortage of generating plant, combined with the necessity for ensuring the greatest possible economy in consumption at all times, owing to the inadequacy of the coal supplies. As a result, it is recorded that, during the period under review, load had to be shed on 82 days, the maximum cut in any area being about 25 per cent., while the maximum duration was 7 hours. With regard to coal supplies, the maximum stocks at the beginning of the winter were 2·297 million tons. This would have lasted only 3·7 weeks with the average winter consumption. As is well known, the abnormal weather conditions in the early months of 1947, however, led to an exceptional increase in consumption, particularly for domestic and non-industrial purposes; and this, combined with serious delays in the transport of coal, necessitated the prohibition of the consumption of electricity at the beginning of February for industrial power (except for certain essential purposes) in the London and South East England, Central England and North West England and North Wales areas. This prohibition was quickly followed by an embargo on the use of electricity for all purposes in residential and other non-industrial premises throughout the country during certain hours of the day. The voltage was also reduced by 5 per cent. The restrictions on industrial consumption were wholly withdrawn by the beginning of March, but continued, with certain modifications, on domestic premises until September 30, 1947. As shown by figures subsequently published, the effect on the output during February, 1947, was considerable, but thereafter there was a rapid recovery, though not at so high a rate as might have been expected under normal conditions.

The existence of many difficulties on the constructional side is also recorded. These included shortages of labour and material for the construction and extension of generating stations. The shortage of wooden poles for rural development was also acute and undertakings were asked to consider alternatives, including reinforced concrete, for which a standard specification was drawn up.

After a reference to the Electricity Act, 1947, the report turns to statistics, from which it appears that during the period under review, 564 undertakings held powers to supply electricity and that 344 generating stations were in operation, or two less than in the previous year. The amount of electricity generated during the year ended December 31, 1946, was 41,252,550,045 kWh, an increase of 3,968 million kWh, or 10·6 per cent. on the figures for 1945. Of this amount, 96·99 per cent. was generated by steam plant, the average number of kilowatt-hours produced per ton of coal and coke consumed being 1,568, compared with 1,578 in 1945. The amount of coal and coke consumed was 25,482,933 tons, an increase of 2,661,845 tons, or 11·7 per cent. over the figures of the previous year. Of the 344 stations, 88 had individual outputs of 100,000,000 kWh, or more, and accounted collectively for an output of about 38,490 million kWh, or 93·31 per cent. of the total. There were 142 "selected" stations in existence on December 31, 1946, and these accounted for 39,556 million kWh, or 96 per cent. of the total. The electricity sold amounted to

* *Twenty-Second Report of the Electricity Commissioners.* London: H.M. Stationery Office. [Price 2s. 6d. net.]

34,033,920,000 kWh, an increase of 3,122,480,000 kWh, or 10·1 per cent. over the figure for 1945.

During the period under review the aggregate of new generating plant sanctioned amounted to 2,104,840 kW, compared with 917,475 kW in 1945-46, while the total capacity of the plant installed was 12,400,000 kW. The generating plant sanctioned for the initial sections of eight new stations amounted to 774,000 kW. In addition, 28 consents were given to the installation of 1,310,790 kW in existing stations. In this connection, reference is made to the fact that the objections to the proposal by the North Metropolitan Power Station Company to build a 64-MW station at Rye House, Hertfordshire, were disallowed after inquiries had been held both by the Commissioners and the Minister of Town and Country Planning. Reference is also made to the objections to the proposal of the City of London Electric Lighting Company to extend their station at Bankside by the installation of 100 MW of plant. A local inquiry was held into this objection but, after the date of the report, formal consent was given to the construction of the station, provided oil-firing was adopted, that the most efficient methods for eliminating smoke and sooty emissions and for preventing the discharge of sulphur were continually used and that the station buildings were set back to allow the construction of a road and promenade. During the year ended March 31, 1947, 37 consents were issued to the establishment or extension of main transmission lines by the Central Electricity Board and other authorised undertakings.

FLAMEPROOF TRANSFORMER PANEL FOR COAL-FACE LIGHTING.

THE progress that is now being made, by the use of fluorescent or incandescent lamps, towards the more efficient lighting of the coal face renders it necessary, for safety reasons, that the circuits supplying this equipment shall be adequately controlled. To deal with this problem the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, have developed a coal-face lighting panel. This has been designed to comply with the conditions necessary for the grant of the appropriate flameproof certificates, and is suitable for use in fiery mines and petroleum laden atmospheres.

The unit consists essentially of a skid-mounted welded-steel enclosure, the overall dimensions of which are 36¼ in. high by 32½ in. wide (including the skids) and 17 in. deep (23 in. over the plugs). This enclosure is divided horizontally into two compartments, the upper of which forms a flameproof 'bus-bar chamber and contains an isolating switch. This switch is fully interlocked with the front cover, so that the latter can be removed only when the switch is off. The lower compartment houses a removable chassis weighing 114 lb., on which are mounted a transformer, contactors, overload and earth-leakage relays and fuses. The transformer has an output of 2·5 kVA at 110 volts. The primary winding is provided with tappings so that it can be connected to 440, 500, 550 or 600 volt circuits. By mounting the components in this way, it is claimed that maintenance is facilitated, especially if spare chassis are kept available. Coupling plates can be supplied to join two or more units.

The incoming cables can be connected on either side of the 'bus-bar chamber, while the trailing cables for the lighting circuits are supplied through two 30-ampere four-pin flameproof plugs and sockets on the front of that chamber. In the event of an overload the appropriate relay operates a trip and opens a contactor in the affected circuit, the other being left in commission. The earth-leakage relay is connected in the contactor-coil circuits, which are completed through the pilot and earth cores of the trailing cables. These two cores are solidly connected in the last lamp fitting on the cable. Should a leakage to earth of 5 amperes occur on either lamp circuit, the relay will therefore operate, opening both contactor-coil circuits and isolating the whole of the lighting installation. At the same time, a second set of contacts on this relay will be closed, thus lighting an indicating lamp which is visible through a window in the front cover.

The four-pin flameproof plugs for the lighting circuits and the flameproof couplers for joining the units are inserted and withdrawn by turning a knurled nut. The pilot pins are shorter than the power pins, so that the pilot circuit is broken first, thus causing the contactor to open the power circuit before the power pins are withdrawn.

The lighting fittings are connected in pairs through a 5-yard length of four-core trailing cable. Each fitting is also connected to a 2½-yard length of cable, complete with half a flameproof coupler, thus forming a self-contained 10-yard continuous lighting section. Consecutive sections can be quickly joined together by couplers and the complete assembly connected to the lighting panel.

LABOUR NOTES.

AT the annual conference of the Chemical Workers' Union, a resolution was adopted calling for nationalisation of the chemical industry in this country. Supporting the proposal, Mr. Edwards, the acting general secretary of the union, stressed the vital importance to British basic industries of such chemicals as sulphuric acid, caustic soda, and soda ash, and to the national health of such products as penicillin and various new drugs; and submitted that the whole patent medicine industry should be the subject of an immediate Government inquiry.

Another resolution adopted by the conference called for an immediate inquiry into the affairs of I.G. Farbenindustrie with the object of nationalising it. Supporting the proposal, Mr. Edwards said that between the two wars, German monopoly had controlled 28 per cent. of the world's chemical trade, and was responsible for over 2,000 cartel agreements.

Speaking at a luncheon of the American Chamber of Commerce, in London last week, Mr. Hugh Gaitskell, the Minister of Fuel and Power, said that Britain had a "reasonably good" chance of attaining her 1948 targets for coal production and export, but another spurt in output would be needed in the autumn if that were to be done. Opencast coal output in the previous week had reached a new peak figure of 352,000 tons; a year ago it was 215,300 tons.

According to official figures relating to the coal mining industry, the deep-mined coal output in the week which ended on April 17 was 3,917,000 tons, compared with 3,905,300 tons in the previous week. This increase was achieved in spite of a rise in the tonnage lost by disputes and other causes, which increased from 84,400 tons to 101,000 tons. The total output the week before last was 4,269,000 tons—the second best figure this year—compared with 4,224,100 tons in the previous week.

There were 723,500 wage earners on the books of collieries at April 17—a rise of 200 in seven days—but coal-face miners were 200 fewer at 291,600. Among coal-face miners, 7·40 per cent. were voluntarily absent against 7·20 per cent. in the previous week, and the involuntary figure rose from 5·73 per cent. to 5·84—7 per cent. For all mine employees, the voluntary percentage increased to 5·67 from 5·63, and the involuntary to 5·07 from 4·96.

The Crisis Committee's further meetings with the Chancellor of the Exchequer were apparently satisfactory, for their report on them was accepted and approved by the General Council at a meeting in London on Wednesday last week. An official announcement issued after Wednesday's meeting said that the General Council had decided that there were "most encouraging indications" that the policy of the Chancellor of the Exchequer, in dealing with limitations of profits and control of prices, would accomplish its objects. "It was realised," the statement continues, "that because of the uncertainty of the future movement of essential prices, the probable course of domestic prices and the cost of living could not yet be clearly estimated." The Crisis Committee is to review the position at intervals of at least three months.

Mr. Beard, the general secretary, states in the April issue of the *Trade Report* of the United Patternmakers' Association, that there has been considerable activity and development in connection with the apprentice question in several industries. "In the light-casting industry, for instance," he writes, "we have been successful in obtaining an increase of 3*s.* per week for those in the first two years of apprenticeship and one of 5*s.* per week for the remaining three years. In addition, a tool allowance has been granted of 1*s.*, 2*s.*, and 3*s.* for the last three years, which will rank for the payment of overtime and holiday credits. This is a question we have been pursuing with these employers for a considerable time, and I am, therefore, happy to record that settlement has now been effected."

"The question of recruitment and training," Mr. Beard says, "has also been the subject of discussion with the engineering employers. An agreement on this matter was entered into, a considerable time ago, in which main principles were accepted by a tripartite committee consisting of the unions, the employers, and the Ministry of Labour. It was obvious that this agreement would have to be implemented by some sort of industrial agreement with the engineering employers, and considerable delay has been experienced in resolving the matter. So much so that many branches have written in for news of the progress of this scheme, so that they could make it their business to get representation upon any local committee which was set up to allocate apprentices for our particular industry."

"A recent meeting with the Ministry of Labour and the employers resulted," Mr. Beard writes, "in a formulation of further guiding principles; and, at a meeting between the trade unions and the employers on March 17, the subject was again considered. Briefly, it is now expected that the local committees of the Confederation and the engineering employers will view the question in the light of setting up committees to deal with recruitment and training. The Ministry of Labour, however, insist that, in the first place, the question of apprenticeship should be one for the boy and his parent and the Juvenile Employment Officer; and when the boy has expressed a preference for a particular job—if such a preference is available—then the recruitment and training committees will assist, in accordance with the original tripartite agreement."

Conferences on the subject have also taken place between the craft unions which have members employed by the I.C.I. and the I.C.I. This large company, it is stated, have never admitted the right of trade unions to negotiate on behalf of apprentices, "although it is true to say," Mr. Beard writes, "that conditions of training and wages are extremely favourable to our young members when a comparison is made with other industries. The whole question has been fully discussed. We found a reaction—on the part of the I.C.I.—which was favourable to ourselves, and a sub-committee was set up to frame proposals which will then be submitted to the main body with a view to an agreement." In this connection, Mr. Beard expresses the opinion, "that the training and educational schemes which the I.C.I. have in hand for craftsmen apprentices are extremely good, and could with advantage, be copied by many other employers."

Presiding at a meeting of the National Joint Advisory Council for Industry, on Wednesday last week, Mr. Isaacs called attention to the debate in the House of Commons on April 22 on the Monopoly (Inquiry and Control) Bill, particularly to the following statement by the Lord President: "The Minister of Labour is proposing to bring before the N.J.A.C. the general question of restrictive labour practices. Both employers and trade unions are represented on that council which affords the best forum for a preliminary discussion of the manner in which restrictive labour practices, which are alleged to impede production and industrial expansion, should be investigated." A general exchange of opinions followed, in the course of which reference was made to the Restoration of Pre-war Practices Act, 1942. In view of the necessity to consult the constituent organisations, it was decided that the council should resume discussion of the matter at a later date.

Regulations governing the employment of persons in industrial establishments in Afghanistan came into force early in 1946. In a preamble to them, it is stated that the regulations are based on two fundamental principles: (1) Liberty to each individual to choose his occupation; each individual is free to choose any legally authorised occupation, provided that he obtains written permission from the Ministry of National Economy, and conforms in the exercise of the occupation he has chosen to the instructions of the public authorities. (2) Protection of employees by the application of the following rules: (*a*) Regular Payment to them of their full remuneration; (*b*) Compensation for accidents occurring during work; (*c*) Fixing of working hours in accordance with what is fair and reasonable; (*d*) Weekly rest day; (*e*) Accident prevention; (*f*) Health measures.

It is stipulated that no employer may engage a operative or other employee without first concluding with him a written contract of employment. Cancellation of the contract is subject to previous notice of one month. Wages are to be fixed by mutual agreement between the employee and the employer and are to be specified in the contract. It is illegal to pay wages in kind. Wages must be paid regularly and in full each month and working hours are fixed. The employee is entitled to one hour rest-break during the day. Young persons between 18 and 20 years of age are to work only seven hours a day, but as is the case with the other employees they are entitled to an hour's rest-break a day.

Every employee is entitled to 20 days' paid holiday a year and one month's holiday in case of sickness. In the case of apprentices the annual holiday is only 15 days, but the holiday in case of sickness is the same for apprentices as it is for their elders. Friday is observed as the weekly rest day.

BRAKE WHEELS AND WALLOWERS.

FIG. 1. CLASP-ARM BRAKE WHEEL; LITTLE CRESSINGHAM, NORFOLK.

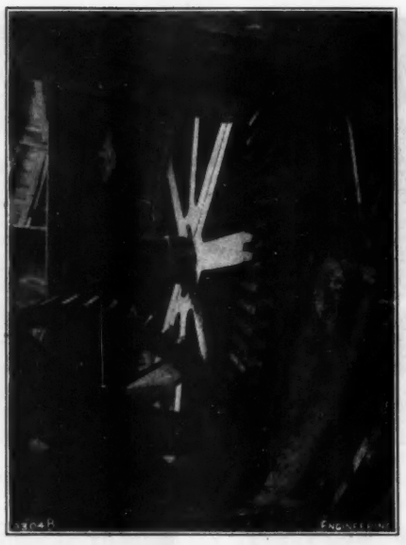


FIG. 2. WHEEL WITH SEPARATE BRAKE RIM; WICKLEWOOD, NORFOLK.

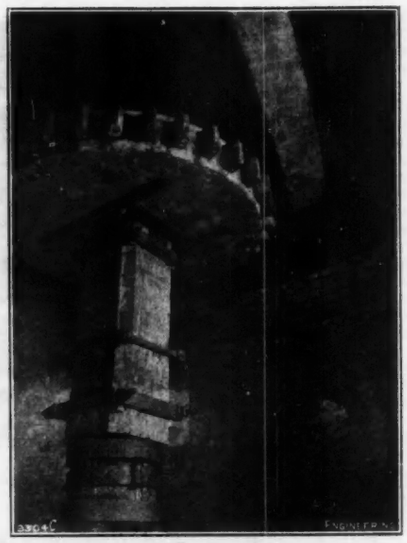


FIG. 3. SOLID WOODEN WALLOWER; BLAKENEY, NORFOLK.

BRAKE WHEELS AND WALLOWERS.*

By the late H. O. CLARK and REX WAILES, M.I.Mech.E.

THE "brake," "gripe" or "head" wheel in a windmill is mounted on the "windshaft," which carries the sails. Its position on the windshaft is fairly forward near the head in post mills, and at about the centre in tower mills. It is the main driving gear in the mill, owing its name to the fact that a contracting brake or "gripe" acts on its rim. The earliest type of brake wheel consists of two wooden arms mortised at right angles through the wooden windshaft, into which they are wedged. To these arms are bolted four "cants," and in front of the cants are fixed the strakes or felloes of the rim, into which the wooden cogs are mortised, and on which the brake acts; this type of construction is known as the "compass arm" wheel. Sometimes three double arms are to be met with, as in Nantucket Mill, Massachusetts. The construction is simple, but the mortises weaken the windshaft at the place where strength is most needed. In the tower mills in La Mancha, Spain, the arms are strengthened with pairs of cross braces held in position with blocks of wood, the outer being called "crucera" and the inner "imprenta." The Dutch mill books from 1728 onwards are the first to show the improved "clasp-arm" wheel. In this type four arms are used. Instead of being passed through the shaft they are arranged to form a hollow square at the centre, as shown in Fig. 1, herewith, through which the windshaft passes. Occasionally additional stays are placed between the arms, as at Klein-Wolkau tower mill in South Prussia; or they are strengthened with a frame fixed in front of them, as at Besthorpe tower mill in Norfolk. There are from four to eight cants, and these and the rim are frequently doubled to give depth and strength. At Caston tower mill, Norfolk, the arms are 20 in. deep and at Brill post mill, Buckinghamshire, the rim is held between the pairs of arms. At the back of the wheel the arms are sometimes moulded at their ends; cants moulded ornamentally could be seen in Harpswell post mill, Lincolnshire.

The components of the wheel are either bolted or are pinned together with wooden pegs, and the wheel is usually hung on the windshaft, with 16 keys, two at each corner, front and back, as shown in Fig. 4, on page 454. In the case of a wooden windshaft, almost the whole square at the centre of the wheel is filled, but, when an iron shaft has been fitted subsequently, either wood packing or a two-piece cast-iron box (Fig. 5) is used to fill the gap (another example is illustrated in Fig. 6, page 454), or two square plates or four horns are cast on the shaft to carry the wheel. Occasionally the wheel is braced to the wooden windshaft at the front, as at Ashton tower mill, Somerset. Sometimes a wheel has been converted from a "compass" to a "clasp-arm" wheel, and in this case the marks where the old arms were bolted on will be seen on the cants. The inner edge is often recessed to take the end of an arm, or the arm may be dovetailed in; the arms themselves are often halved at this point and always at their point of intersection with each other. Oak is the timber commonly used, though elm, beech, and hornbeam have been noted, while elm is frequently used for the rim.

The introduction of cast iron into millwork made lighter wheels possible. In some cases, iron hubs and arms were fitted to wooden cants and rims; in others, the wheel had a wooden rim only, in which case the arms were dovetailed into it, as in Kent, or bolted up to it. Wheels completely of iron are also to be met with. Six or eight arms of cruciform section are usual, though T-section arms are also to be found. They are hung on their iron windshafts on a square or four horns, usually with eight keys, and for the most part are cast in halves, though a few have been noted cast solid. At Kingsland Mill, Anglesey, a plate is cast at the end of each spoke and to these plates are bolted the sections of the iron rim. These in turn have plates cast on their sides which serve to hold the teeth of the wheel, which is cast in sections.

One of the most curious brake wheels was to be seen at the wind and water mill at Legbourn, Lincolnshire, where two brake-wheel hub and arm castings were mounted on the windshaft and held the wooden cants of the wheel between them. The largest wheel met with was at Diss tower mill in Norfolk, 11 ft. 6 in. in diameter; 10 ft. diameter is not unusual. Caston tower mill in Norfolk, shown in Fig. 9, page 454, has a massive wheel of this diameter, with curved cants 18½ in. wide and a rim 14 in. wide.

The teeth of wooden brake wheels are often wooden cogs mortised through the rim. Alternatively, cogs are cast in iron in segments, the old wooden cogs sawn off and the segments bolted on. Wheels with iron rims may have the cogs cast solid with the rim or segments bolted on or wooden cogs mortised in. The angle of inclination of the windshaft varies between 5 deg. and 15 deg. to the horizontal, and with a low inclination the brake wheel becomes virtually a face gear. The face of the rim is usually at right angles to the axis of the windshaft, though occasionally it is bevelled slightly, as at Ingham tower mill, in Norfolk. The rim usually takes the wear of the brake, but at Wicklewood Mill, in Norfolk (Fig. 2), a separate cast-iron brake rim was bolted to the spokes of the iron brake wheel. At Great Sanghall tower mill in Cheshire, the 11-in. wide rim is faced with iron. Sometimes two rows of cogs are provided on a brake wheel; in such cases, the inner row is for the drive to the machine for dressing the bran from the flour. Examples of this could be seen at the composite mill at Banham, in Norfolk, and in the post mills at Great Gransden, in Huntingdonshire, and Ramsey in Essex. The most curious gear was encountered in the post mill moved from Ellington, in Huntingdonshire, to Madingley, in Cambridgeshire. Two rows of staggered applewood cogs of 4-in. pitch and 3-in. face drive a solid iron wallower with two similar rows of staggered teeth cast on it.

In England, the most usual type of brake or gripe is a thick elm or poplar band in six or eight lengths, held together with iron plates and bolts, and extending round the brake wheel, one end being anchored to the cap frame on one side and the other being attached to the brake lever on the same side. The lever itself is a heavy beam, normally of wood, occasionally of iron, and varying in section and length. It holds the brake on by its own weight, sometimes assisted by a weight hung on the end. In the smock mill at Nantucket, Massachusetts, this is a box of stones; in Stevington post mill, Bedfordshire, it is a stone weight with an iron ring attached by a staple leaded in to the stone.

To release the brake, the lever is raised by means of a rope anchored to the end of the lever, running over the pulley above it and down to some position from which the sails can be seen easily, so that they can be stopped in the desired position. Use is sometimes made of a multiplying gear, such as a three-sheave block or pulleys, with a ratio of about 4 to 1. The lever is held in the off position by an ingenious swinging catch having one slot into which a pin on the lever falls. The example shown in Fig. 7, page 454, is at Upminster. To release the lever and apply the brake, it is only necessary to pull the brake rope, thus raising the lever and allowing the catch to swing free. The engagement and disengagement of the catch can be felt down the brake rope, but quick action is required to effect this operation. The application of the brake must be made carefully as by stopping the sails too suddenly they may be broken off and thrown. An iron brake band, either split or whole, such as is illustrated in Fig. 8, page 454, is often used and this is sometimes faced with wooden blocks, usually of elm, strung on to a light square iron rod. This type was much favoured in the Norfolk marsh mills, where the brake lever is called the "fang staff" (from the Dutch *vang stock*). In France, a thin one-piece wooden brake is sometimes met with, and at Chinnor, in Oxfordshire, the wooden brake was faced with iron.

It is not always realised how large these brakes can be; that at North Mill, Wymondham, in Norfolk, is 8 in. wide and 9 in. deep. Supports from the roof are necessary at the top to keep the brake in position. In Spain, a V-shaped groove is sometimes cut in the brake-wheel rim for the brake to work in. At Palling tower mill, in Norfolk, the brake acted on a flat-bottomed groove cast on the rim of the iron brake wheel, while at Wicklewood tower mill, in the same county, a separate rim of cast iron is bolted on to the spokes of the brake wheel. A similar wooden rim was held with staples to the brake wheel at Salters Lode smock mill, Norfolk. Abroad, the brake may act on the bottom half of the brake wheel only, as in the Boyd Mill, Portsmouth, Rhode Island, or on the top half, as in the post mill at Deuden-bei-Delitzch in South Prussia.

The brake will only hold the wheel if the sails tend to turn in their normal direction. Should the mill be tail-winded and the sails turn backwards, the brake becomes useless, and for this reason a safety chain is often provided and the brake wheel chained up to the cap frame if the mill is left standing. It is also sometimes wedged with a baulk of timber. Should the mill

* Paper read at a meeting of the Newcomen Society, held in London on April 14, 1948. Abridged.

BRAKE WHEELS AND WALLOWERS.

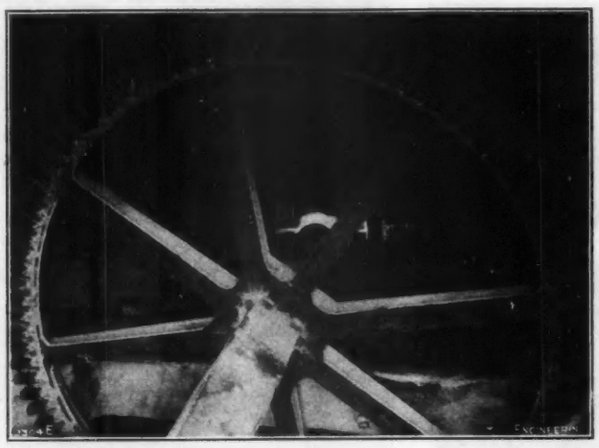


FIG. 4. TYPICAL IRON BRAKE WHEEL; BURGH-LE-MARSH, LINCOLNSHIRE.

FIG. 5. WOODEN CLASP-ARM BRAKE WHEEL; SUTTON, NORFOLK.

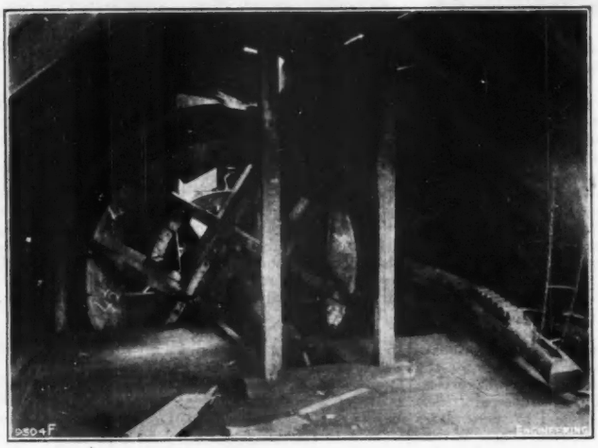


FIG. 6. CONVERTED WOODEN BRAKE WHEEL; OLD BUCKENHAM, NORFOLK.

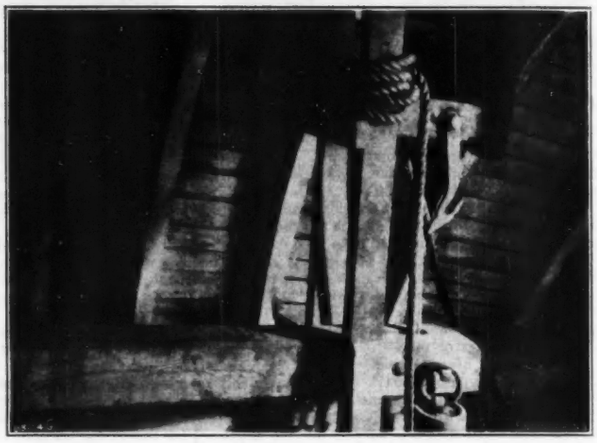


FIG. 7. BRAKE CATCH AT UPMINSTER, ESSEX.

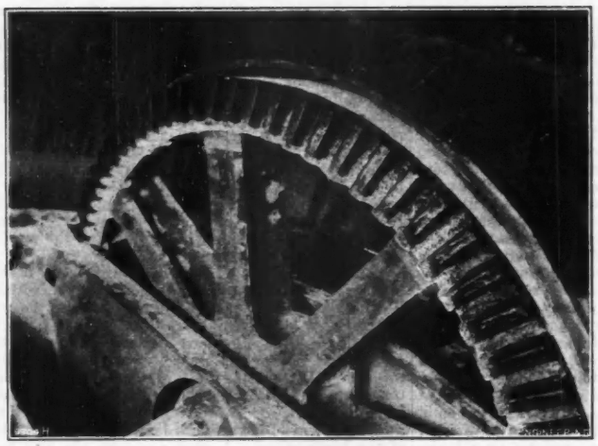


FIG. 8. IRON BRAKE ACTING ON IRON WHEEL; COLEBY HEATH, LINCOLNSHIRE.

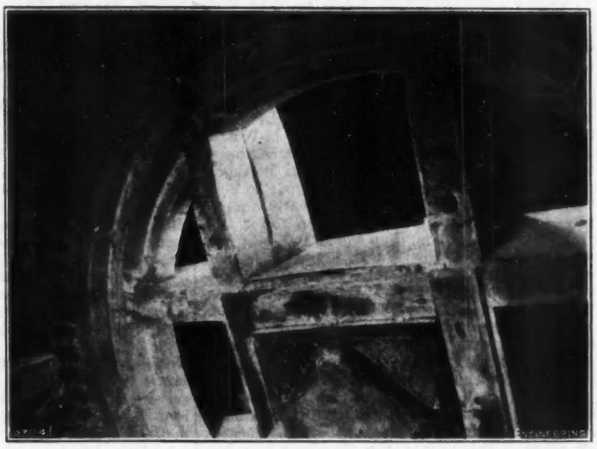


FIG. 9. WOODEN WHEEL WITH CURVED CANTS; CASTON, NORFOLK.

tend to run away in a storm and the brake fail to hold, the miller may try loading all the stones with the maximum amount of grain they will take, and, opening the shutters, let the mill run; or, in the case of a mill with no fantail, he may "quarter" the sails, by turning them at 90 deg. to the direction of the wind.

The "wallower" is a term given to the wheel which is driven directly by the brake wheel and is behind it. In Bozeat post mill, Northamptonshire, the tower mills at Vejer de la Frontera in Andalusia, and the composite mill at Rödgen-bei-Delitzch in South Prussia, however, the wallowers are in front of the brake wheel. The first wallowers were lantern pinions and, though no longer found in England, they can be seen in Europe and America; in fact, the French name for wallower is *la lanterne* and the Spanish *linterna*. The staves of the lantern wheel are fixed at top and bottom into two flanges. When worn, they can be turned round and the wheel moved up or down on its spindle so that a fresh wearing position is afforded. The development of the lantern wheel is the "pin gear," known as the "trundle" or "cow-pop" gear, which resembles a lantern wheel of large diameter with no top flange and with more and shorter staves. Such a trundle gear is usually of

clasp-arm construction. The most usual type of wallower is in effect a crown wheel of wood or iron, with most of the variations associated with brake wheels. Iron wheels with or without wooden cogs are as much favoured as wooden wheels, which are sometimes solid, Fig. 3, page 453. When stones are driven directly from the brake wheel, as is often the case in old post mills and primitive tower mills, the wallower also functions as a stone nut. The most curious example was seen at the post mill at Deuden-bei-Delitzch, in South Prussia, where two pairs of stones side by side in the breast of the mill were driven directly by two skew lantern pinions. At Chatham Mill, Massachusetts, the wallower is a 16-tooth spur wheel, and a wooden clasp-arm spur-geared wallower can be seen in Carter's Mill, Halvergate Marshes, in Norfolk. The largest wallower examined was at Great Saughall Mill, in Cheshire. This was a compass-arm wheel 7 ft. in diameter, with iron segment teeth. The wheel was flat and the teeth slightly bevelled. A trundle-wheel wallower at Lutton Gowts Mill, in Lincolnshire, was 6 ft. 3 in. in diameter and of clasp-arm construction.

The methods of mounting wallowers on their upright shafts vary considerably. Usually, they are hung on wedges and packing, either of which may be of wood or iron. In post mills, they are sometimes mounted on the top of a great spurwheel; and at Stoke Ferry tower mill, in Norfolk, the wallower is hung on by wooden wedges to a cast-iron octagon sleeve, mounted on top of the wooden upright shaft. To put the wallower out of gear with the brake wheel, sometimes slip cogs were removed from one or the other. In other cases, the cap of the top bearing of the upright shaft carrying the wallower was removed and the top of the shaft moved sideways, bringing the wallower out of engagement. At Great Ellingham tower mill, in Norfolk, two adjusting screws and shackles were provided on the top of the shaft for this purpose. The ratio of the drive from brake wheel to wallower varies according to whether the stones are driven by the wallower or not, and if indirectly, according to the ratio of the drive from the great spurwheel to the stone nuts. In the former case, the ratio may be as low as 6 to 1; in the latter, as high as 1½ to 1.

LAUNCHES AND TRIAL TRIPS.

S.S. "CALEDONIAN MONARCH."—Single-screw cargo vessel built by the Caledon Shipbuilding and Engineering Company, Limited, Caledon Shipyard, Dundee, to the order of the Monarch Steamship Company, Limited (Managers, Messrs. Raeburn and Verel, Limited), West Nile-street, Glasgow, C.1. Main dimensions: 447 ft. by 56 ft. 6 in. by 36 ft. 6 in. to shelter deck; deadweight capacity, 10,000 tons. Triple-expansion engines, of 2,500 indicated horse-power, supplied by Messrs. John G. Kincaid and Company, Limited, East Hamilton-street, Greenock. Service speed 11 knots. Launch, April 22.

M.S. "BORBA."—Single-screw cargo vessel with accommodation for twelve passengers, built and engined by Messrs. William Doxford and Sons, Limited, Pallion, Sunderland, for the Sociedade Geral de Commercio, Industria e Transportes, Ltda., Lisbon. Main dimensions: 424 ft. by 53 ft. 9 in. by 25 ft. 6 in.; deadweight capacity, about 7,000 tons. Four-cylinder Doxford opposed-piston oil engine, giving a service speed of over 13 knots. Launch, April 23.

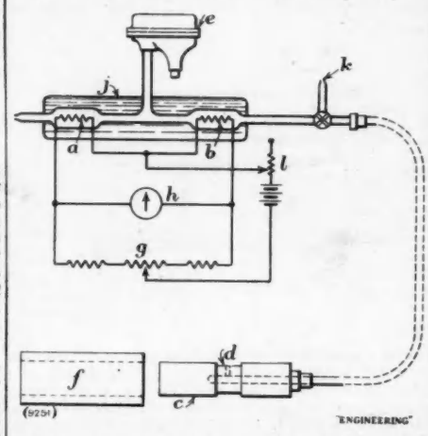
M.S. "ATHELKNIGHT."—Single-screw cargo vessel for the carriage of molasses in bulk, built by Sir James Laing and Sons, Limited, Deptford Yard, Sunderland, for the Athel Line, Limited, Brook House, Park-lane, London, W.1. Main dimensions: 465 ft. by 63 ft. 2 in. by 34 ft. 7 in.; deadweight capacity, 12,500 tons on a draught of 28 ft. 2 in. Four-cylinder Doxford-type engine supplied by the North Eastern Marine Engineering Company (1938), Limited, Wallsend-on-Tyne, giving a speed in service of 12½ knots. Launch, April 23.

S.S. "AVONDENE."—Single-screw cargo vessel, built by Messrs. William Gray and Company, Limited, Central Shipyard, West Hartlepool, to the order of the Dene Shipping Company, Limited, St. Mary Axe, London, E.C.3, for the River Plate trade. Main dimensions: 406 ft. by 56 ft. by 36 ft. 4½ in. to shelter deck; carrying capacity, 8,900 tons on a draught of 25 ft. 0½ in. Triple-expansion engines, constructed by the Central Marine Engine Works of the builders, with two oil-fired boilers, producing a service speed of 10½ knots. Launch, April 23.

M.S. "COPELAND."—Twin-screw cargo vessel, with refrigerated space for the carriage of dairy produce, built by the Caledon Shipbuilding and Engineering Company, Limited, Caledon Shipyard, Dundee, for the Belfast-London trade of the Clyde Shipping Company, Limited, 78, Carlton-place, Glasgow, C.5. Main dimensions: 235 ft. by 38 ft. by 18 ft.; deadweight capacity, 1,500 tons. Engines, of Atlas-Diesel type, supplied by Messrs. British Polar Engines, Limited, 139, Helen-street, Govan, Glasgow, to develop collectively 1,920 brake horse-power and give a speed of 13 knots. Trial trip, April 26.

THE "SIGMA" ELECTRO-PNEUMATIC GAUGE.

AN electro-pneumatic comparator gauge for measuring the bore of tubes or cylinders has been developed by the Sigma Instrument Company, Limited, Letchworth, Hertfordshire, and was demonstrated at the Gauge and Tool Exhibition held in London in February last, and described on page 136, *ante*. In this instrument, the escape of air along the clearance between a cylindrical mandrel and the bore into which it is inserted determines the air flow over a heated filament. The temperatures, and consequently the resistance of the filaments, are therefore regulated by the differences between mandrel and bore diameters, and a Wheatstone bridge network is employed to indicate these differences on a meter scaled in one-thousandths of a millimeter. We give below a diagram of the electrical and pneumatic system, from which it will be seen that there are heated filaments *a* and *b* in two arms of the bridge circuit. The mandrel *c* is drilled axially for the incoming air, which escapes through a small hole *d* in the side. Air, which may be taken from a works compressed-air system, or any other convenient source, is first supplied to a pressure governor *e* within the instrument casing, and then divides into two streams. One of these passes over filament *a* and thence through a small hole to the atmosphere; the other airstream passes over filament *b* and then through a pipe or flexible tube to the mandrel. The escape hole in the latter is covered when the work *f* is slipped over, or when the mandrel is inserted into the work. The flow of air across the filament *b* is thereby reduced to an extent which depends upon the relative diameters of mandrel and work. The bridge control *g* enables the bridge to be balanced for a given set of conditions, say, for a specified difference between mandrel and work diameters. Departures from these



conditions disturb the balance on the bridge, and the nature of the resulting deflection on the centre-zero meter *h* shows whether or not the dimensions of the work are within the tolerance limits. The meter can be shunted so as to make a two-range instrument.

The governor ensures a supply of air at constant pressure, and the bridge is further stabilised by mounting the glass tubes housing the filaments in a cooling tank *j* filled with oil. To allow for the gradual fall in battery voltage, a test jet *k* is provided so that the setting of the instrument can be checked periodically. A two-way cock diverts the air stream from the mandrel to the test jet, and for a given setting of the control *g* the meter should then read zero. If this is not the case, the control *l* is used to restore balance, and the air stream is then switched over to the mandrel. It is understood that the calibration of out-of-balance currents in terms of the differences between mandrel and work diameters is carried out by the manufacturer by allowing a jet of air to flow across a small gap and impinge on a flat face, the width of the gap being adjusted by micrometer. A relationship between gap widths and meter readings is thus established, and this enables the meter to be scaled dimensionally.

The instrument can be used also to indicate the straightness of a tube or hole. For this purpose, a separate mandrel is provided, the work being slipped over and located with respect to the escape hole by means of a stop. If the bore of the work is straight rotation of the work on the mandrel about its axis will not affect the meter readings. Any curvature, however, will cause variations in the clearance between the escape hole and the work, and these will be shown by variations in the meter readings. The equipment is readily portable, the bridge and its controls being housed in a metal case at the rear of which are connections for the battery and air supply.

NOTES ON NEW BOOKS.

Elementary Differential Equations. By PROFESSOR LYMAN M. KELLS. Third edition. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York, 18, U.S.A. [Price 3 dols.]; and McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 18*s.*]

FOR this new edition, Professor Kells has revised the original text extensively. Fresh material has been incorporated, existing treatments have been expanded, and fuller theoretical discussions included. The first part deals with ordinary differential equations of the first order and the first degree; of the first order and of degree higher than the first; linear differential equations with constant coefficients; and miscellaneous differential equations of order higher than the first. A clear treatment of singular solutions is given. This is followed by a chapter on differential equations in more than two variables, in which statements of existence theorems are given without formal proof; and one on solutions by series and by methods involving successive approximations in which the Legendre and Bessel equations are introduced.

The second part is devoted to partial differential equations of the first order and of order higher than the first. The stress laid on the determination of arbitrary functions, satisfying specifically assigned boundary conditions, is a valuable feature as it serves to remove the sense of disquiet so apt to afflict the student due to the apparent vagueness of the general solutions. Operator methods are introduced early and used largely. All the more important types of differential equation are discussed and, in the chapters headed "Applications," emphasis is laid on those most frequently encountered in practice. Illustrations are drawn from mechanics, vibratory motion, electricity, wave motion, conduction of heat, and fluid motion. The answers to the examples worked out in the text, being printed in bold-face type, are readily distinguishable. Comprehensive sets of problems are provided. These are suitably graded and afford ample exercise in setting up differential equations, solving them subject to stated initial and boundary conditions, and interpreting the solutions. There are a few typographical errors. The sign of equality is turned through a right angle in equation 17, on page 241, an "e" is missing from the equation at the foot of page 272, and $\frac{\partial^2 x}{\partial x\,\partial t}$ on page 277 should read $\frac{\partial^2 i}{\partial x\,\partial t}$. Instead of changing over from e and i on page 100 to ϵ and j on page 136 for the exponential and the imaginary unit, respectively, it would be more consistent to employ the latter notations throughout. In general, it may be said that this clearly written first course in differential equations is well adapted to the requirements of engineering students.

Science at War. By J. G. CROWTHER and PROFESSOR R. WHIDDINGTON, F.R.S. H.M. Stationery Office, York House, Kingsway, London, W.C.2. [Price 2*s.* 6*d.* net.]

THE authors of this book were commissioned to write it by the Scientific Advisory Committee to the Cabinet, whose chairman, Sir Henry Dale, F.R.S., contributes an explanatory foreword. The object, Sir Henry explains, "was to make available to the public an authoritative account of some of the more important aspects of the scientific contribution to the war effort, based on the official archives, but so written as to be acceptable to the reader without special scientific education." To his further remark, that "the reader must judge for himself the extent to which we have realised this intention," we may respond at once that the joint authors appear to have achieved it with notable success, and with a complete absence of the air of "writing down" to an uninformed intelligence that has been rather unfortunately prominent in some official publications about the war. The book does not attempt to embrace every application of science to the war effort, but its four sections—dealing, respectively, with "Radar," "Operational Research," "The Atomic Bomb" and "Science and the Sea"—cover a wide field. The illustrations are well chosen, and the line diagrams are generally adequate, though some charts are rather excessively reduced. The book would be improved, however, by the addition of an index; and it deserves a more robust cover.

Boiler House and Power Station Chemistry. By WILFRID FRANCIS, Ph.D. Second edition. Edward Arnold and Company, Limited, 41 and 43, Maddox-street, London, W.1. [Price 21*s.* net.]

THE second edition of this book differs from the first mainly by the inclusion of more recent knowledge concerning the nature of coal, and the description of additional and improved methods of analysis. It is as a practical laboratory handbook for the power-station chemist who will find it most serviceable; for, however much a reader may be interested in the

somewhat lengthy portion dealing with the origin, classification and micrographic appearance of coals, there is not much that can be done about such matters. The remainder of the work appears to cover every kind of analysis or chemical test in connection with coal, ash, water and oil that could fall to the lot of a works chemist; refractories are not dealt with. The information as to the reagents to be used and to the methods of conducting the tests is admirably clear; the set-up of the apparatus is illustrated when necessary. The usual calculations relating to combustion and boiler efficiency are also exemplified; and there is a good deal of useful advice about the cause and avoidance of boiler trouble. The volume is well worthy of a place in the laboratory of any large power plant.

Yacht Racing. By BROOKE HECKSTALL-SMITH. Third edition, revised and enlarged by G. SAMBROOKE STURGESS. Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.1. [Price 25s. net.]

ERSKINE CHILDERS, whose classic, *The Riddle of the Sands*, is still probably the best piece of yachting fiction extant, comments in it upon that "extraordinary book, *Bradshaw*, turned to from habit, even when least wanted, as men fondle guns and rods in the close season." The late Major Heckstall-Smith's books on yachting surely come into the same eclectic category, and a new edition of *Yacht Racing*, after an interval of some 14 years, must be regarded as an event. As the sub-title indicates, the book includes "a complete exposition of the revised rules of racing as amended and re-adopted by the International Yacht Racing Union conference, held in London, November, 1946." As secretary of the Yacht Racing Association for rather more than 45 years, Major Heckstall-Smith enjoyed a special position in the eyes of yachting men; and Mr. Sambrooke Sturgess, a member of Council of the Y.R.A., and vice-commodore of the Norfolk Broads Yacht Club, is particularly well fitted to undertake the revision needed to bring the book up to date. As a work of reference, it can claim a peculiar authority, with the added recommendation that it can be enjoyed by those who have no knotty problems in hand for solution equally with those who have.

CATALOGUES.

Electric Cables.—Aberdare Cables, Limited, Aberdare, Glamorgan, have issued a well-illustrated brochure giving details of the electric cables manufactured by them and of the methods employed in their production.

Diesel Engines.—We have received from Messrs. Davey, Paxman and Company, Limited, Standard Ironworks, Colchester, a copy of catalogue number 1206 which gives details of their series RQ and RW Diesel engines.

Lighting Fittings for Industrial Purposes.—Industrial lighting fittings of various types for use with tungsten lamps are illustrated in a pamphlet published by Messrs. Philips Electrical, Limited, Century House, Shaftesbury-avenue, London, W.C.2.

Axial-Flow Fans.—Messrs. Woods, of Colchester, Limited, Colchester, Essex, have issued a new illustrated booklet on their Series 1 Aerofoil axial-flow fans. These are medium efficiency fans and are intended for general ventilation and industrial purposes.

Mobile Cranes.—We have received from Messrs. George Cohen, Sons and Company, Limited, Wood-lane, Shepherds Bush, London, W.12, a leaflet describing the Jones Super 22 Diesel-driven mobile crane. The leaflet is well illustrated and gives a brief specification of the cranes and also sets out the advantages to be gained by their employment.

Pneumatic Colliery Equipment.—Pneumatic apparatus, which can be applied to colliery operations, is dealt with in a series of leaflets issued by the Westinghouse Brake and Signal Company, Limited, 82, York-way, King's Cross, London, N.1. The subjects covered include power-operated cage gates, the operation and control of airlock doors, tippler loading, and the operation of point layouts.

Rubber-Insulated Cables.—A new catalogue published by W. T. Henley's Telegraph Works Company, Limited, 51, Hatton-garden, London, E.C.1, gives details of the rubber-insulated cables manufactured by them in the C.11A 250-volt and 660-volt grades. Cables with different types of protection are shown separately, and each page covers the complete range of standard sizes for each type.

Hydraulic Pumps and Motors.—Many types of hydraulic pumps and motors are described in a catalogue received from Messrs. Hyland, Limited, Doncaster-road, Wakefield, Yorkshire. The pump and motor shafts rotate in either direction; and the pumps, the pistons of which are operated by a camshaft, do not require clutches, as a lever or wheel is used for disconnecting the drive to the pistons.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.

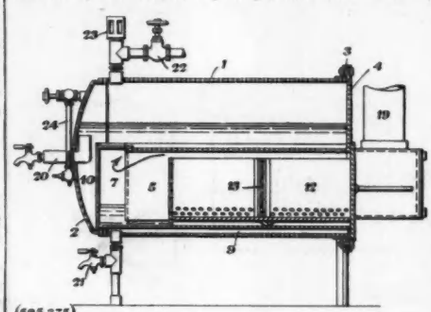
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is given after the abstract in each case, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AGRICULTURAL APPLIANCES.

595,275. Boiler for Water Heating and Steam Raising. Gascoignes (Reading), Limited, and J. A. Kingston, both of Reading, Berkshire. (4 *Figs.*) March 13, 1945.—This invention is a water-heating and steam-raising apparatus capable of burning such fuels as wood, peat and straw. It is of particular use for dairies and farms. The appliance consists of a cylindrical drum 1 closed at one end by a domed plate 2 and having a flange ring 3 welded around the other end of the cylinder. To this flange ring 3 is secured an end plate 4, which carries a firebox unit and forms the end wall of the drum 1. The firebox unit is attached to the mounting plate 4 so as to form a single unit with it. The firebox unit is of U-shape in plan and semi-circular in cross-section, and consists of a pair of tunnel-like ducts, which are closed at their outer ends, but joined together so as to communicate with one another by means of an opening 7 at their inner ends,



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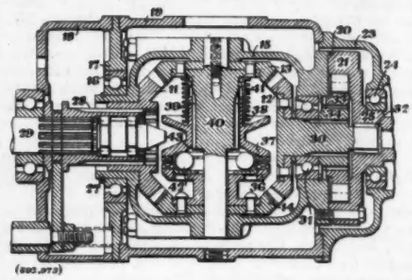
leaving a space between the greater part of the lengths of the two parallel ducts. Narrow spaces 9, 10 are also provided between the side and back end, respectively, of the firebox unit and the opposed wall surfaces of the interior of the drum 1. The spaces ensure speedy heating of the water placed in the body 1 by providing a large heating surface and a free circulation path for the water, thereby utilising effectively the heat of combustion in the fire tube formed by the duct 5. The duct 5 accommodates a removable firebasket 12, of rectangular tray form, which is provided with a transverse removable partition 13 in order that a small or large combustion space may be provided as required. The second duct forms a return flue for the products of combustion and delivers them to the chimney stack 19. The drum is fitted with a hot-water tap 20, drain tap 21, steam stop valve 22, safety valve 23, and gauge glass 24. (*Sealed.*)

MOTOR VEHICLES.

593,973. Synchronising Coupling. Lea-Francis Cars Limited, of Coventry, and J. C. Ridley, of Coventry. (1 *Fig.*) June 21, 1945.—This invention relates to a synchronising power-transmitting coupling which is to be disconnected in certain conditions, and is only to re-engage when substantial synchronism is reached, so that engagement can be effected silently. An ordinary differential gear has co-axial bevel gears 11 and 12 which are interengaged by a pair of diametrically-opposite planet bevel pinions 13 and 14 which can rotate freely in a planet-carrier cage 15. The left-hand side of the cage is supported in a ball bearing 16 held in a partition 17 which is enclosed between the casing parts 18 and 19, and at the other end the cage has an annular-flanged engagement, indicated at 20, with the outer member 21 of a one-way driving clutch to which it is secured by bolts. The member 21 is supported in the casing 23 by a ball bearing 24, and is fast with the driven shaft. The driving bevel gear 11 is journalled within the boss 27 of the cage, and has a sliding splined connection with an axially-slidable sleeve 28 which, in turn, is splined to the driving shaft 29. The bevel gear 12 is carried within the cage by a ball bearing 31 and within the clutch member 21 by needle rollers 32. The inner member 33 of the one-way driving clutch is fast with a sleeve 34 which, in turn, is fast with the hub 30. The planet pinion 14 carries a fixed dog clutch element 36 having teeth directed towards the other planet pinion, which latter is in sliding and driving engagement with a co-acting clutch element 37 which is pressed by a spring 38 into engagement with the fixed clutch element 36. The element 37 is formed on a sleeve 39 which is splined to a spindle 40, the latter being fast with the planet wheel 13 but having the planet wheel 14 journalled on it. The spring 38 is supported on a carrier 41 into which slides the adjacent end of the sleeve 39. The centrifugal means for holding



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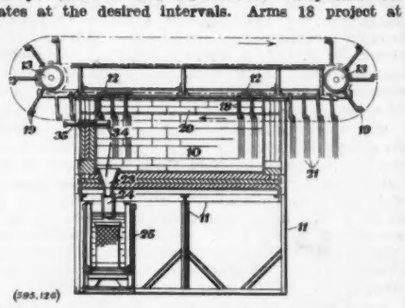
the clutch elements 36 and 37 apart until synchronism is reached, takes the form of balls 42 mounted in a housing provided jointly by the two clutch elements (rotatable with the planet pinions), the proportions being such that when the elements have been separated, the balls will act to hold them separated until the rotational speed of the planets and of the balls about their axis falls to such a low value, as synchronism is being reached, that the dog clutch spring 38 can return the slidable dog clutch element into engagement with the fixed element, the movable wall 43 of the housing forcing the balls radially inwardly out of the operative position. (*Sealed.*)

MISCELLANEOUS.

595,126. Hardening of Steel Articles. English Steel Corporation, Limited, of Sheffield, J. L. Squire, of Sheffield, and A. P. Field, of Stannington, near Sheffield. (4 *Figs.*) June 9, 1944.—The equipment forming the subject of this invention is for hardening steel articles, such as hacksaw blades and other tools, by a process which involves heat treatment followed by quenching. A heating chamber 10 is built on and supported by a framework 11. It is heated by electrical heating elements (not shown), placed in the interior of the chamber and grouped more closely together towards the discharge end of the chamber, which is on the left in the drawing. An endless conveyor 12 is mounted on the roof of the chamber 10 and consists of chains passing around sprocket wheels 13 mounted on bearings which are supported on girders above the furnace. Two conveyor chains are used and are connected by transverse plates at the desired intervals. Arms 18 project at



(595,126)

right angles from the conveyor path, being carried by the plates connecting the two chains. At their free ends the arms 18 carry hooks 19 and those arms which hang from the lower length of the conveyor pass through a slot 20 in the roof of the heating chamber 10 so that, when the conveyor is running, the hooks 19 will travel along the upper region of the heating chamber 10 in the direction of the arrow. At the charging end of the heating chamber, the roof slot 20 is extended in the end wall of the chamber for a sufficient distance to provide entry into the chamber for hacksaw blades 21 suspended on the hooks 19. At the discharge end of the chamber 10, a delivery chute, consisting of an upper conical portion 23 and a lower cylindrical portion 24, passes through the floor of the heating chamber and leads to a quenching bath 25 below the heating chamber. An adjustable abutment 34 is carried by a rod 35 above the chute 23, 24 and is placed in the path of the hacksaw blades 21 or other articles to be hardened. As each article makes contact with the abutment it is displaced from its hook and falls into the chute 23, 24, by which it is guided into the quenching bath. (*Sealed.*)